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# Ostracodes of the "Winifrede Limestone" (Middle Pennsylvanian) in the Region of the Proposed Pennsylvanian System Stratotype, West Virginia

by

I. G. Sohn

Paleontological Research Institution
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# OSTRACODES OF THE "WINIFREDE LIMESTONE" (MIDDLE PENNSYLVANIAN) IN THE REGION OF THE PROPOSED PENNSYLVANIAN SYSTEM STRATOTYPE, WEST VIRGINIA

By

I. G. Sohn

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## ABSTRACT

The Winifrede Limestone of R. V. Hennen* occurs in the upper one-third of the Kanawha Formation in central and southern West Virginia. This thin calcareous, fossiliferous shale represents one of the most widespread marine incursions into the central Appalachian basin during the Middle Pennsylvanian. Collections of invertebrate fossils from this marine tongue contain 24 taxa of marine ostracodes assigned herein to 19 genera, one of which, *Amphissites* Girty, 1910, includes the new subgenus *A.* (*Amphikegelites*). The following taxa are new: *A.* (*Amphikegelites*) *henryi, Bairdiolites astigmaticus, Cavellinella? pricei, Kirkbyella* (*Berdanella*) *ricei, "Microparaparchites" reductospinosus, Monoceratina winifredeana, Plavskella englundi, Pseudobythocypris? enigmatica,* and *Shishaella saundersi.* All the new species, previously described species, and species referred to in open nomenclature in this study are present also in rocks of Atokan age in one or more of the following states: Illinois, Indiana, Kentucky, Ohio, Oklahoma, and Texas. Except for *Cavellinella? pricei* n. sp., *Moorites minutus* (Warthin, 1930)?, and *Shishaella saundersi* n. sp., all the taxa are present in rocks of Atokan age either in the Magoffin Member of the Breathitt Formation or in shale above the Hindman coal bed of the Breathitt Formation in Eastern Kentucky. On the basis of known stratigraphic ranges of the ostracode species in states other than West Virginia, the Winifrede Limestone of Hennen correlates with the Atokan Provincial Series of the Midcontinent; the ostracode data verify the age assignment of this marine tongue that is based on the macrofauna.

## INTRODUCTION

The Winifrede Limestone of Hennen (1914) at its type-locality is a fossiliferous dark-gray shale with two thin interbedded limestone beds. This member is 1.86 m (6.1 ft) thick, and its top is about 22.8 m (75 ft) below the base of the Winifrede coal bed at the type-locality in southern Kanawha County, West Virginia (Henry and Gordon, 1979, p. 102). Much of the material for this study (about 11 kg [25 lbs]) was collected from a carbonaceous shale above the Chilton(?) coal bed at the Harewood section (Englund, Arndt, and Henry, 1979, p. 31, Stop 18B) from an interval labelled "Winifrede(?) Limestone" (USGS [U.S. Geological Survey] colln. 12971-PC). This collection yielded more than 4,000 well-preserved ostracode specimens representing all the species herein described as new. According to later work by Henry (oral commun., July, 1981), this collection definitely is derived from Hennen's Winifrede Limestone. Henry and Gordon (1979, p. 102) listed the macrofauna in this interval and suggested an Atokan age. Two collections (USGS collns. 26713-PC and 26774-PC) from the type-locality of the Winifrede also were processed for ostracodes, but the ostracodes at this locality are not so well-preserved, and are lower in abundance and diversity than ostracodes from the Harewood section. All the newly described species have their type-localities in surface outcrops. The relatively few specimens from borehole cores illustrated in this study are shown for comparison. Collecting localities in West Virginia are shown in Text-figure 1. The purpose of this study is to determine the age and correlation of the Winifrede Limestone of Hennen (1914).

## ACKNOWLEDGMENTS

I thank the following U.S. Geological Survey colleagues: T. W. Henry, for the collections that instigated this study and for sharing his field notes and expertise; W. V. Sliter, for relieving me of other commitments so that I could complete this paper; and Mackenzie Gordon, Jr., for providing me with previously collected samples from the type-locality of the Winifrede Limestone of Hennen (1914) and for encouragement and advice during the study.

The SEM (Scanning Electron Microscope) micrographs are by Mr. Walter R. Brown, and the prints are by H. E. Mochizuki. S. C. Bergman, T. M. Kehn, C. L. Rice, and V. M. Seiders, of the U.S. Geological

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* 1914. *in* Krebs, C. E., and Teets, D. D., Jr., Kanawha County, West Va. Geol. Survey [County Rept.], p. xxvi–xxviii.

Survey, and John Beard, of the Kentucky Geological Survey, collected the samples in Kentucky. Drs. Alan S. Horowitz, of the University of Indiana, and R. H. Shaver, of the Indiana Geological Survey, made available Shaver's types and identified specimens for comparison. Dr. L. W. Knox, of the Tennessee Technological University, donated copies of his unpublished plates (Knox, 1975). Dr. H. H. Bradfield, Dallas, Texas, presented me with specimens other than types from his 1935 publication, and the late Dr. M. F. Marple donated topotypes of *Sansabella stewartae* Marple, 1952.

## AGE OF THE OSTRACODES

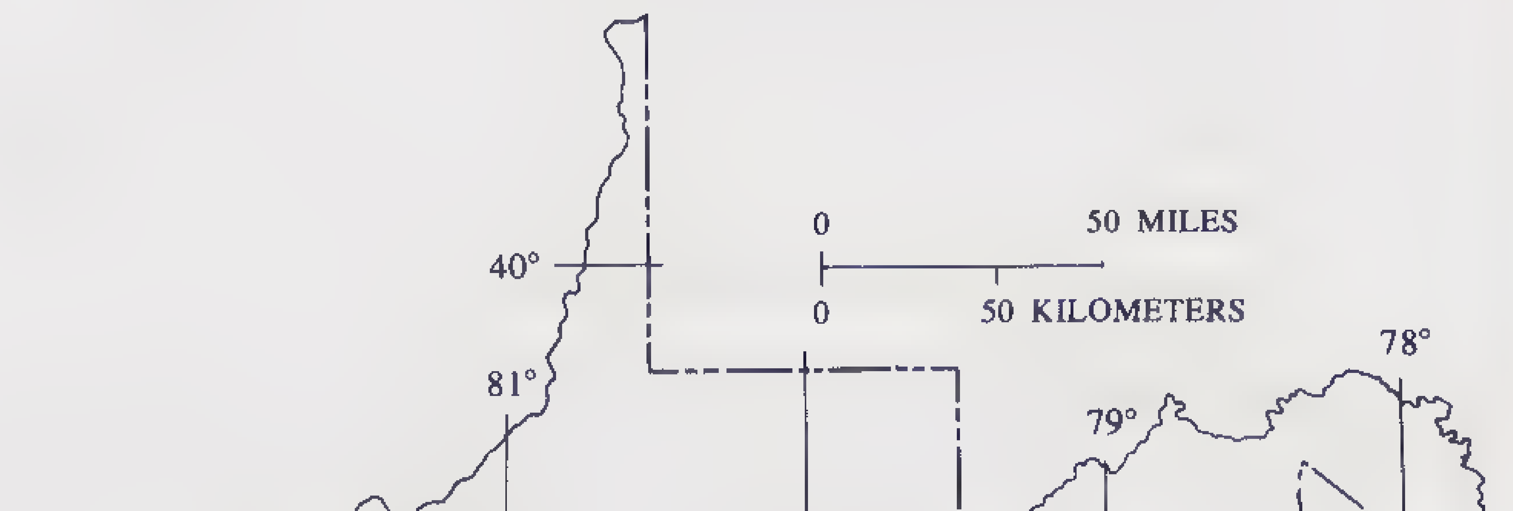
The ostracodes in the Winifrede Limestone of Hennen (1914) are Atokan in age (Text-fig. 2). *Amphissites* (*Amphikegelites*) *henryi* n. sp., *Aurikirkbya* ex gr. *A. triseriata* Shaver, 1959, *Kirkbya magna* Roth *sensu* Cooper, 1946, "*Microparaparchites*" *reductospinosus* n. sp., *Bairdia isoscelata* Shaver, 1959, and *Orthobairdia oklahomaensis* (Harlton, 1927) are present in the Atokan part of the Tradewater Formation in Butler County, Kentucky (USGS colln. 12974-PC), additional evidence for an Atokan age of the Winifrede Limestone of Hennen (1914). The ostracodes, however, cannot be used to resolve which part of the Atokan is represented by Hennen's Winifrede Limestone. Species illustrated in this study and their occurrence in West Virginia and Kentucky are shown in Table 1. In this table, those taxa that are illustrated on Plates 1–11 bear an "x", those mentioned in the discussions of the taxa and documented by voucher specimens deposited in the U.S. National Museum of Natural History (USNM) bear an "o", and those specimens, not deposited in the USNM, that were identified in samples from boreholes in West Virginia and surface samples in Kentucky, bear a "+". The borehole samples in West Virginia are aggregated under a single USGS collection number for that borehole; individual collection numbers are listed in the Appendix.

The following species in West Virginia have not yet been identified in Kentucky: *Amphissites* (*A.*) sp. aff. *A. robertsi* Morey, 1935, *Amphissites* (*Amphikegelites*) n. sp. A, *Pseudobythocypris*? *enigmatica* n. sp., and *Shishaella saundersi* n. sp.

Table 2 shows the stratigraphic ranges outside of West Virginia of the new and identified ostracode species in the Winifrede Limestone of Hennen (1914). The age of Hennen's Winifrede Limestone is deduced from this table.

*Plavskella englundi* n. sp., *Cavellinella*? *pricei* n. sp., "*Microparaparchites*" *reductospinosus* n. sp., and *Bairdiolites astigmaticus* n. sp., are present also in the Morrowan of Kentucky and Oklahoma and are therefore not usable for age determination of Hennen's Winifrede Limestone. *Healdia ehlersi* Bradfield, 1935, *Orthobairdia oklahomaensis* (Harlton, 1927), and *Pseudobythocypris pediformis* (Knight, 1928) have been recorded in younger Pennsylvanian rocks; consequently, they are also not usable for correlation of Hennen's Winifrede Limestone. The remaining nine taxa listed in Table 2 are restricted to rocks of Atokan age. Hennen's Winifrede Limestone in West Virginia contains eight species in common with the Magoffin Member of the Breathitt Formation in eastern Kentucky (Table 1; USGS colln. 21413-PC) and six additional species in common with collections from the shale above the Hindman coal bed in eastern Kentucky (Table 1; USGS collns. 12920-PC, 12923-PC, and 12927-PC). The Hindman coal bed is about 76.2 m (250 ft) above the base of the Magoffin Member (Rice and Smith, 1980, fig. 1, measured section 3).

The Magoffin Member of the Breathitt Formation is early Atokan in age (Rice *et al.*, 1979, p. F18). This member is about 70 m (230 ft) above the base of the



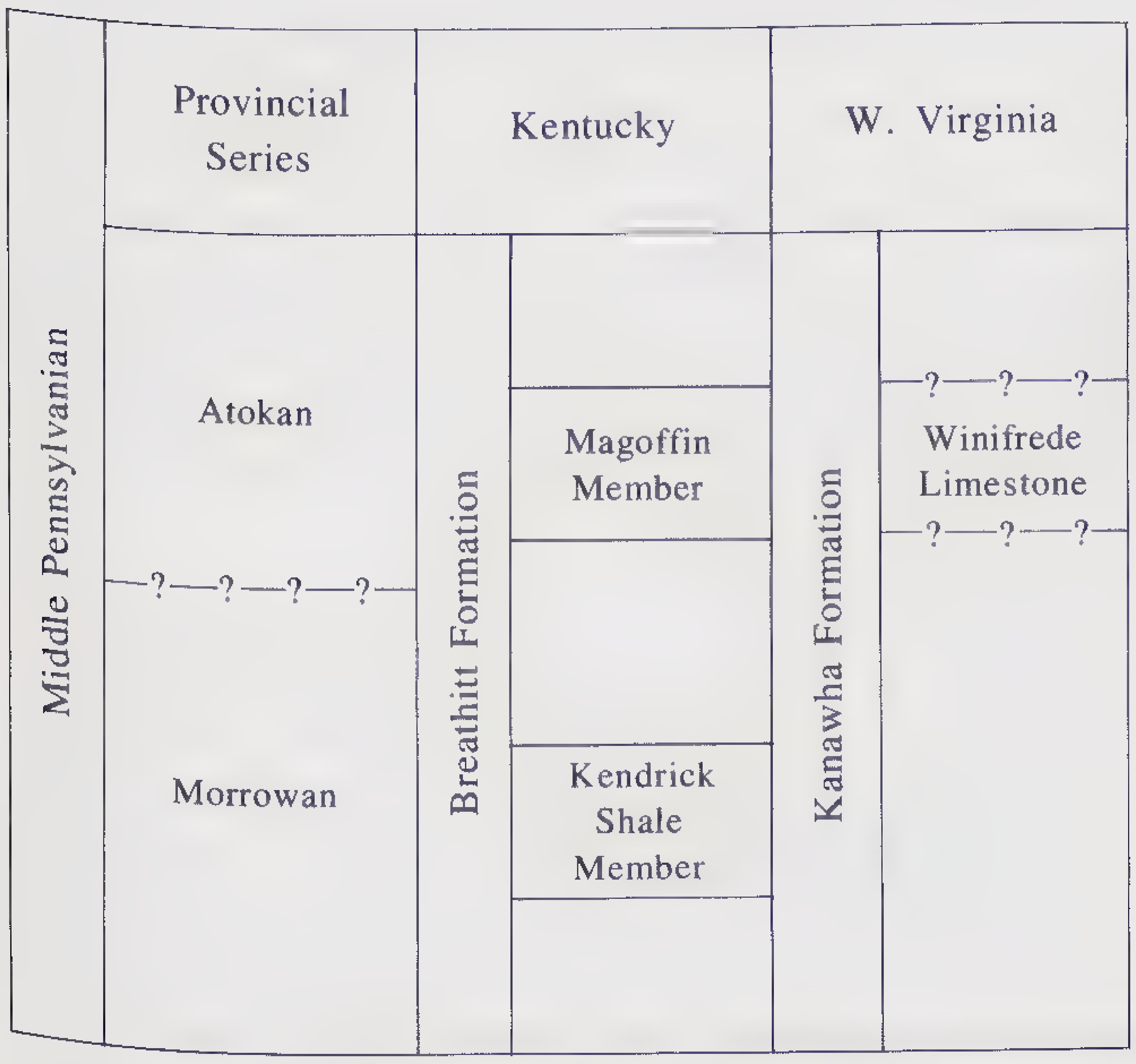

Text-figure 1.—Map showing the location of collecting localities in West Virginia. Localities are described in the Appendix.

Kendrick Shale Member (Morrowan) of the Breathitt Formation in the area of the type-section, and about 140 m (460 ft) above the base of the Kendrick Shale Member in the area of its reference-section (Rice, 1980, p. A119). The ostracodes in Hennen's Winifrede Limestone corroborate Henry and Gordon's (1979, p. 102) suggested Atokan age for Hennen's Winifrede Limestone, which is based on marine megafossils and the correlation with the Magoffin Member of the Breathitt Formation in eastern Kentucky.

## PALEOECOLOGY

Arndt *et al.* (1979, p. 29) and Flores and Arndt (1979, p. 115) postulated a depositional model for the Middle Pennsylvanian Series in the proposed Pennsylvanian System stratotype in West Virginia. They interpreted the strata that comprise the Winifrede Limestone of Hennen (1914) to have been deposited in a shallow marine bay. The Harewood section, from which most of the ostracodes illustrated herein were collected, is represented in that model as a marine bay-fill deposit. Because all the ostracodes in Hennen's Winifrede Limestone are marine, they confirm the above model of deposition.

The absence of species of nonmarine ostracode genera, known from Pennsylvanian deposits (Sohn, 1977a), that would have to have been distributed passively, as described by Victor, Dance, and Hynes (1981), indicates that the Winifrede Limestone of Hennen (1914) was deposited at a distance sufficiently removed from




Text-figure 2.—Suggested correlation of Hennen's Winifrede Limestone in West Virginia and the Magoffin Member of the Breathitt Formation in Kentucky.

the delta plain that contemporaneous freshwater forms did not reach those areas.

Among the marine ostracode species in the Winifrede Limestone of Hennen (1914), some belong to groups (genera, families, or superfamilies) that were probably burrowers and others belong to groups that I think were probably capable of swimming, because their descendants swim. Burrowers are those ostracodes that lacked swimming setae; these consist of two groups that have a certain amount of ecologic overlap. One group of burrowers lives in the substrate. These burrowers part the sediment particles as they crawl; the other group consists of ostracodes that move within the pores between the sediment particles—true interstitial and subterranean forms. Swimmers are those ostracodes that have swimming setae that enable them to lift themselves into the water column to move from one place to another or from one plant to another.

The probable burrowers are:

**Species in *Cavellinella* Bradfield, 1935, in the Platycopida of Sars, 1866.** Living species of *Cytherella* Jones, 1849, in the same Order, are incapable of swimming.

**Species in *Healdia* Roundy, 1926, and in *Pseudobythocypris* Shaver, 1958, [superfamily Healdiacea Harlton, 1933].** Hartmann and Puri (1974, p. 18) tentatively assigned the living Saipanettidae McKenzie, 1968, to the Healdiacea. Maddocks (1972, p. 30) was of the opinion that the Saipanettidae should be retained in the Healdiacea as originally suggested by McKenzie (1967, p. 112). She illustrated the antennule of a male of *Saipanetta bensoni* Maddocks, 1972 (p. 34, fig. 3b), a form that is incapable of swimming. McKenzie (1967, p. 107, fig. 2a) illustrated the first antenna (antennule) of the type-species, *Saipanella cloudi* (= *Saipanetta* McKenzie, 1968) that has on the fifth and sixth segments long "trailing sensory bristles" that are feathered. The second antenna (McKenzie, 1967, fig. 2b) is without natatory bristles, and, therefore, the organism was incapable of swimming.

**Species in *Monoceratina* Roth, 1928, in the superfamily Cytheracea Baird, 1850.** Most members of this group are incapable of swimming.

**Species in *Pseudoparaparchites* Kellett, 1933, *Kirkbyella* (*Berdanella*) Sohn, 1961, and *Moorites minutus* (Warthin, 1930), which are relatively small and have a weak hinge structure.** These three genera and *Plavskella* Samoilova, 1951, have an overall similarity to certain interstitial subterranean nonmarine ostracodes of post-Paleozoic age (Danielopol, 1980); consequently, they were probably crawlers.

**Species in *Bairdia* McCoy, 1844, *Bairdiacypris* Bradfield, 1935, and *Bairdiolites* Croneis and Gale, 1939, in the superfamily Bairdiacea Sars, 1888.** Sylvester-Bradley (*in* Moore, 1961, p. Q201) noted that post-Paleozoic species of *Bairdia* have been regarded as close relatives of the freshwater genus *Cypris* Müller, 1776, and have been united with that genus in the Cyprididae Baird, 1850. It should be noted that the Cyprididae are swimmers as opposed to crawlers and burrowers. Although the soft parts of the two groups are indeed closely related, Maddocks (1969) illustrated antennae of living Bairdiidae that do not have swimming setae. Nothing is known regarding the soft anatomy (appendages) of the Paleozoic representatives in the Bairdiacea, and although the superfamily may be polyphyletic, a non-swimming ability is assumed for the group.

Table 1.—Occurrence of Pennsylvanian ostracode species illustrated or recorded in West Virginia and Kentucky. X = illustrated specimen, O = voucher specimens deposited in the collections of U.S. National Museum of Natural History (USNM), and +, ?+ = occurrence not documented by voucher specimens. All collections from boreholes in West Virginia are listed under a single number here and in the Appendix.

x – illustrated specimen
o – voucher specimen in USNM
+ – present in collection
?+ – identification uncertain

| | WEST VIRGINIA | | | | | | | | | | KENTUCKY | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 26774-PC | 12971-PC | 12917-PC | 25656-PC | 12908-PC | 25690-PC | 25644-PC | 25725-PC | 25726-PC | 25727-PC | 12920-PC | 12923-PC | 12926-PC | 12927-PC | 12948-PC | 21413-PC | 12974-PC | 21604-PC |
| *Amphissites (A.)* sp. aff. *A. robertsi* Morey, 1935 | | | o | | | | | | | x | | | | | | | | |
| *Amphissites (Amphikegelites) henryi* n. sp. | x | x | x | o | o | o | o | x | o | x | | o | | o | | x | + | |
| *A. (A.)* n. sp. A. | | | x | + | + | | | | | | | | | | | | | |
| *A. (A.)* spp. | | + | | + | + | + | + | | | | | | | | | | | |
| *Kegelites* spp. | | + | | + | x | + | | | | | | | | + | | | | |
| *Aurikirkbya* ex gr. *A. triseriata* Shaver, 1959 | | | x | x | + | + | ?+ | | | | | o | x | + | + | + | x | |
| *Kirkbya magna* Roth sensu Cooper, 1946 | | | | x | | | | | | | | o | | | | + | | |
| Kirkbyidae indet. | | + | | + | + | + | + | | | | | | + | + | | | | |
| *Kirkbyella (Berdanella) ricei* n. sp. | | + | x | | | | o | | | | | | | x | | | | |
| *Moorites minutus* (Warthin, 1930)? | | | | x | | | | | | | | | | | | | | |
| *Moorites* spp | | | o | | | | + | | | | x | o | | x | | | | |
| *Pseudoparaparchites* spp | | | ?+ | x | | | | | | | x | | | | | | | |
| "*Microparaparchites*" *reductospinosus* n. sp. | x | x | x | | | x | | | | o | o | o | | + | | x | + | o |
| *Sansabella stewartae* Marple, 1952 | x | | o | | | | o | | | | o | | | + | | | | |
| *Plavskella englundi* n. sp. | x | x | o | o | | | | | | o | + | | | | | o | | o |
| *Shishaella saundersi* n. sp. | | x | | | | | | | | | | | | | | | | |
| *Bairdia isoscelata* Shaver, 1959 | | o | x | + | | | | | | | | | | | | | + | |
| *Orthobairdia oklahomaensis* (Harlton, 1927) | | | x | + | | | | | | | ?+ | o | + | + | | | + | |
| *Bairdiolites astigmaticus* n. sp. | | x | ?+ | o | ?+ | | | | | | | | | | | | | o |
| *Bairdiacypris* cf. *B. rectiformis* (Shaver, 1959) | | x | o | x | + | ?+ | ?+ | | o | o | o | o | | | | | | |
| *Bairdiacypris* spp. | | + | | + | | | | | | | + | | + | + | | | + | |
| *Bairdiidae* spp. undet. | | + | | + | | | | | | | + | | + | + | | | | |
| *Monoceratina winifredeana* n. sp. | | x | x | + | ?+ | | | | o | | o | o | | + | | x | | |
| *M.* aff. *M. macoupeni* Scott and Borger, 1941 | | x | x | + | | | | | x | | | | | | | x | | |
| *Healdia ehlersi* Bradfield, 1935 | x | x | x | o | + | | | | o | | | o | | | x | + | | |
| *Healdia* spp. | | + | | + | | | + | | | | + | | | + | | | | |
| *Pseudobythocypris pediformis* (Knight, 1928) | x | x | | + | | | | | | | | | | + | | o | | |
| *P.? enigmatica* n. sp. | x | x | o | + | | | ?+ | | | | | | | | | | | |
| *Cavellinella? pricei* n. sp. | | x | o | o | | + | + | | | | | | | | | | | o |

The probable swimmers are:

**Species in the genus *Sansabella* Roundy, 1926.** The spinelets illustrated on Pl. 4, figs. 20, 21, 23 suggest the presence of a marginal frill that would negate a burrowing habit. Bless (1967, p. 104) suggested that *Sansabella* was a burrower.

**Species in *Amphissites* Girty, 1910, in the superfamily Kirkbyacea Ulrich and Bassler, 1906.** The marginal frills and flanges in this group (Sohn, 1961, p. 115, fig. 18) would serve as obstacles to burrowing activity.

No evidence exists from which to infer the ecologic niche of *Shishaella* Sohn, 1971, and of "*Microparaparchites*" *reductospinosus* n. sp. The weak hinge and structure of the carapace of the latter suggest a low-energy environment, as postulated by Rice *et al*. (1979, p. F19) for the Magoffin Member of the Breathitt Formation in Kentucky where this species is also present. They interpreted the Breathitt Formation to have been

Table 2.—Stratigraphic ranges of Pennsylvanian ostracode species outside West Virginia. 1—Illinois, 2—Indiana, 3—Kentucky, 4—Missouri, 5—Ohio, 6—Oklahoma.

| | PENNSYLVANIAN | | | | |
|---|---|---|---|---|---|
| | Morrowan | Atokan | Des Moinesian | Missourian | Virgilian |
| *Plavskella englundi* n. sp. | 3,6 | 3 | | | |
| *Cavellinella? pricei* n. sp.˙ | 3,?6 | 2,3,5 | | | |
| "*Microparaparchites*" *reductospinosus* n. sp. | 3 | 3 | | | |
| *Bairdiolites astigmaticus* n. sp. | 3 | 3 | | | |
| *Amphissites (Amphikegelites) henryi* n. sp. | | 3 | | | |
| *A. (A.)* n. sp. A. | | 2,5 | | | |
| *Kirkbya magna* Roth sensu Cooper, 1946 | | 3 | | | |
| *Aurikirkbya* ex gr. *A. triseriata* Shaver, 1959 | | 3 | | | |
| *Kirkbyella (Berdanella) ricei* n. sp. | | 3,?5 | | | |
| *Sansabella stewartae* Marple, 1952 | | 3,5 | | | |
| *Bairdia isoscelata* Shaver, 1959 | | 3 | | | |
| *Bairdiacypris* cf. *B. rectiformis* (Shaver, 1959) | | 1,3,5 | | | |
| *Monoceratina winifredeana* n. sp. | | 3 | | | |
| *Healdia ehlersi* Bradfield, 1935 | | 1,2,3,5 | 1,2,6 | 1 | |
| *Pseudobythocypris pediformis* (Knight, 1928) | | 1,3 | 1,4 | 1 | 1 |
| *Orthobairdia oklahomaensis* (Harlton, 1927) | | 3,5,6 | 1,4,6,7 | 4 | 2,7 |

deposited in small shallow bays or tidal channels. Hennen's Winifrede Limestone was also deposited in such an environment.

The swimming ostracodes could have been omnivorous; the presence of marine vegetation (thallose algae) during Pennsylvanian time in the shallow bays suggests that some were probably herbivorous. The crawling ostracodes probably fed on detritus.

The species in West Virginia that have been recorded from Illinois, Indiana, Kentucky, Ohio, and as far away as Oklahoma and Texas (Table 2) indicate that ostracodes were widely distributed in Middle Pennsylvanian seas west and southwest of West Virginia.

## STRATIGRAPHY

The Winifrede Limestone was named for an exposure in the north bank of North Hollow of Fields Creek, south of the mining community of Winifrede, Kanawha County, West Virginia (Hennen, 1914, p. xxvi). This limestone (unit 17 of Hennen, 1914) at its type-locality consists of about 0.15 m (6 in) to 0.3 m (1 ft) of impure fossiliferous limestone and occurs about 21.6 m (71 ft) below the Winifrede coal bed and about 14.9 m (49 ft) above what may be the Chilton coal bed. According to T. W. Henry (oral commun., July, 1981), the Winifrede includes more than unit 17 of Hennen (1914), because the fossiliferous dark-gray shale (1.86 m (6.1 ft) thick, with its top about 22.8 m (75 ft) below the base of the Winifrede coal bed) should be added. Hennen's Winifrede occurs in about the upper one-third of the Kanawha Formation as used by Krebs and Teets (1914). According to Henry and Gordon (1979, p. 102), Hennen's Winifrede is represented at the Harewood section in Fayette County by units 112 and 113 (Englund, Arndt, and Henry, 1979, p. 29); most of the illustrated ostracodes were collected from the Harewood section. Henry and Gordon (1979, p. 102) listed an extensive mega-invertebrate assemblage and stated that this assemblage appears to be post-Morrowan and that an Atokan age is suggested.

## SYSTEMATIC PALEONTOLOGY

### INTRODUCTION

#### Laboratory Techniques

Except for the recent Quaternary-O method and preparation for the use of the scanning electron microscope (SEM), the techniques to disaggregate rocks in order to remove ostracodes, pick them, and prepare them for study and photography have been described by Sohn (*in* Moore, 1961, pp. Q64–Q70). The new developments are discussed below.

*Quaternary-O.*—Quaternary-O (Q-O) is a highly concentrated commercial detergent designed for industrial use (to clean machined products). For use in micropaleontology, one part of alcohol and two parts of Q-O are mixed in a blender at low speed. The Q-O is added slowly to one of the several types of alcohol and mixed until it is completely dispersed and a smooth "stock" solution is formed. One part of the dispersed Q-O ("stock" solution) is diluted with five parts of warm water, and enough such solution is added to cover a sample in a metal vessel. The pot is covered to prevent evaporation and to preserve the concentration of the Q-O in solution and the mixture is simmered for one or more hours. Vigorous boiling causes suds that may lift microfossils and cause them to overflow and dry on the hot stove. Repeated heating and cooling cycles may help break down the rocks. When breakdown is complete, the sample is washed through a screen in the usual manner; thorough final washing with warm water is necessary to prevent formation of a white crystalline deposit on the fossils.

*The Scanning Electron Microscope.*—SEM photomicrography differs from conventional photography in that the picture is not produced by light reflected from an object, but rather is a record of the emission of low-energy (secondary) electrons caused by electron bombardment of an object in a vacuum chamber. The primary electron beam scans (moves across the specimen) in the same manner as in a television camera, and the emitted electrons are collected and converted into a magnified video image of the specimen. This image is photographed to provide a picture. Those electrons that do not contribute to the video signal are drained from the specimen by an ultrathin coating of gold or one of several other metals that conducts the charge to a grounded metal stub to which the specimen is attached by one of several adhesive substances.

I paint a narrow band along the periphery of the metal stub that is inserted into the vacuum chamber of the SEM with a dilute solution of Elmer's Glue in distilled water, and dry the stub at room temperature for at least 24 hours. Selected ostracodes are then positioned on the thin band of glue with a wet, size 00 camel-hair brush. The moisture on the brush is sufficient to wet the dry glue so that the specimen becomes attached to the stub. The stub and its adherent specimens are then coated with ultrathin layers of carbon and gold-palladium.

If the specimen is to be removed from the stub either for permanent storage or for reorientation for additional views, a drop of water on the specimen will soften the glue. Among others, the carapace illustrated on Plate 4, figures 10–14, was posed twice: figures 12 and 13 were made when the carapace was attached along the ventroanterior margin; for figures 10, 11, and 14, the carapace was removed and repositioned so that the right valve was attached to the stub.

The stub and the attached specimen can be rotated in the vacuum chamber 360° in the horizontal and tilted up to 90° in the vertical plane, features that make it possible to obtain pictures of as many as five views of the attached specimen without breaking the vacuum in the chamber. This variety of possible orientations causes the shadows on SEM micrographs to differ from those in conventional light photographs of fossils in that the light source may not appear to be from the upper left, the convention for orientation of illustrations of fossils on plates. The magnification determined from the settings of the SEM may vary as much as 5% from actual magnification: consequently, several views of the same specimen at the same settings will not have the same magnification. When the scanning beam moves horizontally, the outline of the ostracodes differs slightly from that obtained when the beam scans in the vertical direction; consequently, the outline may not be a direct replica of the original.

## Voucher Specimens

Voucher specimens are specimens other than holotypes, paratypes, and figured specimens that I have identified and deposited in the National Museum of Natural History, Smithsonian Institution, in order to document the presence in the collection of a taxon indicated in the text and on Table 1. Taxa indicated on Table 1 by a "+" or a "?+" are represented either by fragments or by specimens so poorly preserved that their designation by a USNM catalog number is not warranted.

## Measurements

Because most of the measured specimens are single valves, I did not measure the width. All recorded measurements were made by means of a Carl Zeiss binocular microscope using an ocular micrometer that has 0.1 mm divisions, and then the nearest 0.01 mm was visually estimated. Because some of the ostracodes are partly abraded and some have missing parts, I do not consider it worthwhile to use a monocular microscope that has a moving reticle accurate to the nearest 0.001 mm (Sohn, 1950, pp. 38, 39). For specimens that have parts missing (illustrated on Pl. 6, figs. 18, 22; Pl. 10, fig. 11; and Pl. 11, fig. 18), I added a "+" to the measurements in order to show that the specimen is larger than the recorded measurement.

### Format

Except where noted in the discussions, the hierarchy above the generic level follows that of Moore (1961).

### Terminology

The morphologic terms used are defined in the Treatise on Invertebrate Paleontology (Moore, 1961, pp. Q47–Q56).

### Type Repositories

USNM: National Museum of Natural History
Smithsonian Institution
Washington, D.C. 20560 U.S.A.

IU; InUPC: Indiana University Paleontological Collection
Department of Geology
Bloomington, Indiana 47401 U.S.A.

InGS: Indiana Geological Survey
Indiana University
Bloomington, Indiana 47401 U.S.A.

### Collection Localities

All the locality numbers listed in the Appendix are part of the USGS [U.S. Geological Survey] Upper Paleozoic card catalog. Collections from cores in each borehole are listed under the locality number that refers to the location of that borehole, not necessarily in stratigraphic or numerical sequence. The occurrences listed in Table 1 are under the USGS collection number that refers to the location of each borehole, or of each surface collection. E&R = Internal report on referred collection.

### Philosophical Considerations

The current system of zoological nomenclature and classification dates back to the 18th century when Carolus Linnaeus, the Swedish naturalist, popularized in his publications the binominal system of classification. Although this system may not be the best possible method of classification and nomenclature in light of current technological sophistication, it has been universally accepted for more than two centuries. The system offers a language to scientists of all nations for international communication that results in stability in zoological nomenclature. Concepts of classification unique to paleontologists are elucidated by Hoover (1981, p. 38). The concept of a species may and sometimes does differ among paleontologists depending on the group studied and the preservation of the particular collections on hand.

In this study I used the following criteria in discriminating, describing, and naming new taxa on the species and genus level:

1. Adequate preservation.
2. Occurrence at more than one locality, or if from a single locality at least 10 specimens.
3. When present, ontogenetic series, adductor attachment muscle scar patterns, hingement, and dimorphic features.

The identification of previously described species is based on adequately preserved specimens that were compared with type material or published descriptions and illustrations. Where comparative material was not available to me, or if my specimens were inadequately preserved, I used "aff." to indicate that the taxon on hand is related to but not identical with the named species, and "cf." to indicate that the preservation of either the specimens on hand or the types of the named species is inadequate to determine without any doubt the conspecificity of the two. *Aurikirkbya* ex gr. *A. triseriata* Shaver, 1959 was used because I do not consider *Aurikirkbya triseriata* Shaver, 1959 as a species in *Aurikirkbya* Sohn, 1950, and because the revision of the species referred to this genus is beyond the scope of this study.

### Class **OSTRACODA** Latreille, 1802 [1804]

See Sohn (1977b, pp. 8–10) for a discussion of the ordinal classification.

### Order **PALAEOCOPIDA** Henningsmoen, 1953

### Suborder **KIRKBYOCOPINA** Gründel, 1969

### Superfamily **KIRKBYACEA** Ulrich and Bassler, 1906

*Geologic range.*—Devonian through Lower Triassic. Sohn (1970, p. 197) established the family Knightinidae based on *Carinaknightina* Sohn, 1970, from the Lower Triassic in the Salt Range, West Pakistan.

### Family **AMPHISSITIDAE** Knight, 1928

### Genus **AMPHISSITES** Girty, 1910

*Amphissites* Girty, 1910, p. 235; Sohn, 1961, p. 115 (see for synonymy and discussion).

*Type-species.*—*A. rugosus* Girty, 1910, p. 236 [no illustration]. First illustration by Roundy, 1926, p. 7, pl. 1, figs. 1a–c. Fayetteville Shale, Washington County, Arkansas.

*Geologic range.*—Middle Devonian through Permian.

### Subgenus **AMPHISSITES** Girty, 1910

**Amphissites (Amphissites)** sp. aff.
**A. robertsi** Morey, 1935
Plate 1, figures 1–4

*Amphissites robertsi* Morey, 1935, p. 478, pl. 54, fig. 20. [Amsden Formation, Fremont County, Wyoming]; Sohn, 1961, p. 121, pl. 8, figs. 23–26; Sohn, 1975, p. G6, pl. 3, figs. 46–61.

Because only one crushed carapace and a left valve from two borehole cores in the Winifrede Limestone of Hennen (1914) are available, the taxon is presented in open nomenclature. The specimens differ from *Amphissites robertsi* Morey, 1935, from the Mississippian part of the Amsden Formation in Wyoming, in size, in lateral outline, and in that the inner rim does not continue to the dorsal margin.

*Measurements* (in mm).—

| | greatest length | greatest height |
|---|---|---|
| Figured Specimen (USNM 325027; Pl. 1, figs. 1–4) | 0.81 | 0.50 |
| Unfigured Specimen (USNM 325028) | 0.95 | 0.55 |

Morey's (1935) types measure: Lectotype, greatest length 1.01 mm, greatest width 0.59 mm; Paralectotype, greatest length 1.00 mm, greatest height 0.51 mm (Sohn, 1961, p. 121; 1975, p. G6).

*Geographic distribution*.—Rare in borehole cores from the Winifrede Limestone of Hennen (1914) in Fayette County, West Virginia, USGS colln. 25727-PC (USNM 325027), and in Kanawha County, West Virginia, USGS colln. 12917-PC (USNM 325028).

*Geologic age*.—Middle Pennsylvanian (Atokan).

### Subgenus **AMPHIKEGELITES** new subgenus

*Etymology of name*.—Intermediate between *Amphissites* and *Kegelites*.

*Type-species*.—*Amphissites* (*Amphikegelites*) *henryi* n. sp.

*Diagnosis*.—Differs from *Amphissites* Girty, 1910, in lacking distinct anterior node or carina, and from *Kegelites* Coryell and Booth, 1933, in having a dorsal crest (shield).

*Discussion*.—In a previous study (Sohn, 1961, p. 115) I discussed and illustrated the carinae, nodes, and dorsal shield of *Amphissites* and illustrated a specimen (1961, pl. 7, figs. 44, 45) that had retained a fluted marginal rim. My reconstruction (1961, p. 115, text-fig. 18) postulated that the marginal rims and probably the carinae, although generally preserved as smooth lines, may actually have been frills and, thus, may have served an as-yet-unknown physiological function.

The specimen of *Amphissites* sp. aff. *A. robertsi* Morey, 1935, illustrated on Plate 1, figures 1–4 also has a fluted marginal rim and is shown because it is associated with specimens of *Amphissites* (*Amphikegelites*) *henryi* n. sp. in a core (USGS colln. 25727-PC), and to demonstrate the difference between the two subgenera. The hingement is typical of the Amphissitidae (Pl. 1, fig. 5; Pl. 2, figs. 8–10).

In a recent study (Sohn, 1977c, p. 152, pl. 1, figs. 51, 52, pl. 3, figs. 9–13) I described and illustrated Late Mississippian and Early Pennsylvanian specimens in open nomenclature as "*Kegelites*" and commented that they might belong to an as-yet-undescribed genus; this subgenus is here established. A carapace from a borehole core is illustrated herein (Pl. 1, figs. 18, 19) to show the differences among *Amphissites* (*Amphissites*), *A.* (*Amphikegelites*), and *Kegelites* Coryell and Booth, 1933. Members of this group were swimmers.

*Geologic range*.—At present known from the Upper Mississippian to Middle Pennsylvanian.

### **Amphissites (Amphikegelites) henryi** new species

Plate 1, figures 5–7; Plate 2, figures 1–10; Plate 5, figures 10–16; Plate 11, figure 13

*Etymology of name*.—In honor of Dr. Thomas W. Henry, U.S. Geological Survey, who shared his extensive knowledge of the stratigraphy in the stratotype area.

*Holotype*.—USNM 325029.

*Paratypes*.—USNM 325030 through 325034, 325078.

*Type-locality*.—Type locality of the Winifrede Limestone of Hennen (1914), Kanawha County, West Virginia, USGS collns. 26713-PC, 26774-PC.

*Other localities*.—

West Virginia: Fayette County, USGS collns. 12971-PC (USNM 325030), 26774-PC (USNM 325029, 325031), 25725-PC (USNM 325032, 325034, 325078), 25726-PC (USNM 325035), 25727-PC (USNM 325033). Kanawha County, USGS collns. 12908-PC (USNM 325036), 25644-PC (USNM 325037), 25656-PC (USNM 325038), 25669-PC (USNM 325039), 25683-PC (USNM 325064), 25685-PC (USNM 325065), 25688-PC (USNM 325066), 25689-PC (USNM 325067), 25691-PC (USNM 325068).

Kentucky: Leslie County, USGS collns. 12927-PC (USNM 325040), 12923-PC (USNM 168210 [specimen broken]), 21413-PC (USNM 168220). Butler County, USGS colln. 12974-PC.

*Diagnosis*.—Subcentral node not well developed, posterior node capped by strong carina extending to approximate level of kirkbyan pit; with or without shorter, weaker anterior carina; inner ridge with two or three reticulations below pit, starts approximately

two-thirds up posterior margin close to outer rim, extends forward subparallel to and three or four reticulations above outer rim, curves upward subparallel to anterior margin with width of rim bounding walls of reticulations.

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Paratype (USNM 325033; Pl. 5, figs. 11, 12; left valve) | 0.50 | 0.32 |
| Paratype (USNM 325032; Pl. 5, fig. 10; left valve) | 0.80 | 0.47 |
| Paratype (USNM 325078; Pl. 1, figs. 5–7) | 0.80 | 0.47 |
| Holotype (USNM 325029; Pl. 2, figs. 1–4) | 0.81 | 0.40 |
| Paratype (USNM 325031; Pl. 2, figs. 6–10; left valve) | 0.81 | 0.47 |
| Paratype (USNM 325030; Pl. 2, fig. 5; Pl. 5, figs. 15, 16; left valve) | 0.82 | 0.50 |
| Paratype (USNM 325034; Pl. 5, figs. 13, 14) | 0.85 | 0.50 |
| Figured Specimen (USNM 168220; Pl. 11, fig. 13) | 0.78 | 0.48 |

*Discussion.*—The reticulations along the anterior part of the valves tend to be aligned subparallel to the anterior margin so that the walls of the reticulations form elongated ridges. These ridges vary from none (Pl. 2, fig. 1) to three (Pl. 2, fig. 5) and are not capping an anterior node as in *A.* (*Amphissites*) (Pl. 1, fig. 2). One carapace (Pl. 5, figs. 13, 14) has on the right valve a ridge formed by the walls of the reticulations subparallel to the anterior margin that curves backwards and is three reticulations below the anterior portion of the dorsal crest, but has no similar ridge on the left valve.

*Geographic distribution.*—See above, other localities.

*Geologic age.*—Middle Pennsylvanian (Atokan).

### **Amphissites (Amphikegelites)** new species A
Plate 5, figures 17, 18

?*Ectodemites harltoni* Cooper. Marple, 1952, p. 935, pl. 134, fig. 19 [''Lowellville (Poverty Run) Member'' of Pottsville Formation, Muskingum County, Ohio].

not *Ectodemites harltoni* Cooper, 1946, p. 102, pl. 15, fig. 44.

not *Kegelites harltoni* (Cooper). Sohn, 1961, p. 129, pl. 7, figs. 50, 51.

?*Amphissites rothi* Bradfield, 1935. Shaver and Smith, 1974 (part), p. 39, pl. 1, fig. 12 [not figs. 13–16 = *Shleesha pinguis*? (Ulrich and Bassler, 1906)] [''Lead Creek Limestone Member of Mansfield Formation'' (Atokan), Hancock County, Kentucky].

*Discussion.*—Cooper (1946, p. 102) described *Ectodemites harltoni* and illustrated in lateral outline the holotype from the ''Seville Limestone.'' His illustration does not show a ridge on the posterior node like that on the specimen shown on Plate 5, figure 18. He referred *Amphissites* sp. Harlton, 1933, from the Johns Valley Shale (Morrowan), to his species. Marple (1952) illustrated a right valve from the ''Poverty Run (= Lowellville) Member'' of the Pottsville Formation in Ohio that differs from Cooper's holotype in having a ridge on the posterior node, like the one shown on Plate 5, figure 18. Sohn (1961, pl. 7, figs. 50, 51) reillustrated Harlton's specimen of *Amphissites* sp. in dorsal and left views, and that carapace has neither a ridge on the posterior node nor a dorsal crest as shown on Plate 5, figure 17. The carapace designated here as *Amphissites* (*Amphikegelites*) n. sp. A (USNM 325041) is similar to Marple's specimen. Shaver and Smith (1974, pl. 1, figs. 12–16) illustrated a right valve of *Amphissites rothi* Bradfield, 1935 (fig. 12) that has a dorsal shield, and two carapaces that do not have dorsal shields (figs. 13–16). These carapaces belong to *Shleesha* Sohn, 1961. The single right valve (IU 11611) is 0.18 mm long and 0.5 mm high, smaller than the specimen from West Virginia, and its subcentral node and posterior ridge are more subdued. Because the dorsum of the specimen from Ohio was neither illustrated nor discussed by Marple and because the specimen shown by Shaver and Smith (1974, pl. 1, fig. 12) is smaller, some doubt may exist as to the conspecificity of the three; consequently, I am using open nomenclature for the illustrated specimen that was obtained from a borehole core (USGS colln. 12917-PC). Poorly preserved specimens that cannot be assigned to *Amphissites* (*Amphikegelites*) *henryi* n. sp. or this taxon are listed in Table 1 as *A.* (*A.*) spp.

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Figured Specimen (USNM 325041; Pl. 5, figs. 17, 18) | 0.90 | 0.50 |

*Geographic distribution.*—

West Virginia: Kanawha County, USGS colln. 12917-PC (USNM 325041).

?Kentucky: Hancock County.

?Ohio: Muskingum County.

*Geologic age.*—Middle Pennsylvanian (Atokan).

### Genus **KEGELITES** Coryell and Booth, 1933

*Discussion.*—See Sohn (1961, p. 128) for a discussion of this genus. A specimen of this genus from a borehole core in Kanawha County, West Virginia, is illustrated on Plate 1, figures 18, 19. It shows the absence of a dorsal shield that is diagnostic of *Amphissites* (*Amphissites*) and *A.* (*Amphikegelites*), which are illustrated on the same plate. Because specimens of this genus recovered only from borehole cores are

poorly preserved, their occurrences are shown in Table 1 as *Kegelites* spp.

*Geologic range.*—Mississippian through Permian. Although in 1961 I had designated the range to be Upper Mississippian, *K. acutilobatus* Rome, 1971, extended the range to the Tournaisian.

**Kegelites** sp.
Plate 1, figures 18, 19

*Discussion.*—The illustrated specimen clearly does not have a dorsal shield. Although the boundaries between reticulations on the lateral surface tend to form elongated ridges subparallel to the free margins, they do not coalesce below the dorsal margin.

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Figured Specimen (USNM 331632; Pl. 1, figs. 18, 19) | 0.91 | 0.5 |

*Geographic distribution.*—See Table 1.

*Geologic age.*—Middle Pennsylvanian (Atokan).

Family **KIRKBYIDAE** Ulrich and Bassler, 1906

Genus **AURIKIRKBYA** Sohn, 1950b

*Aurikirkbya* Sohn, 1950b, p. 35; Sohn, 1954, p. 9; Sohn, 1961, p. 140.

?*Aurikirkbya* Shaver, 1959, p. 790; Shaver and Smith, 1974, p. 47.

*Type-species.*—*Kirkbya wordensis* Hamilton, 1942, p. 713 [Permian, Glass Mountains, Texas].

*Discussion.*—I had originally (Sohn, 1950b, p. 36) referred *Kirkbya canyonensis* Harlton, 1929, *K. kellettae* Harlton, 1929, and *K. wymeni* Kellett, 1933 to *Aurikirkbya*, but later (Sohn, 1954, p. 9) I noted that *K. canyonensis* was erroneously assigned to this genus. Eight additional species of Pennsylvanian and Permian ages have been described in the genus, including *Aurikirkbya triseriata* Shaver, 1959. Current information indicates that not all the species referred to this genus are congeneric. The group that includes *A. triseriata* should be excluded. Because revision of this genus is beyond the scope of this study, I am referring to the specimens discussed below as *Aurikirkbya* spp. ex gr. *A. triseriata* Shaver, 1959.

*Geologic range.*—Mississippian(?), Pennsylvanian and Permian.

**Aurikirkbya** spp. ex gr. **A. triseriata** Shaver, 1959
Plate 10, figures 3–6; Plate 11, figures 5, 6

*Discussion.*—The specimens illustrated represent more than one species. The individual shown on Plate 10, figures 5, 6 is similar to the holotype of *A. triseriata* Shaver, 1959, in the configuration of the surface lobes. The specimen illustrated on Plate 10, figures 3, 4 differs in that the posterior lobe is separated from the horizontal dorsal lobe. The three rows of vertical reticulations below the marginal rim are, however, diagnostic of *A. triseriata*, according to the original description. The specimen illustrated on Plate 11, figure 6 is more elongate and has a separated posterior lobe that trends diagonally backwards. The specimen illustrated on Plate 11, figure 5 is a juvenile and has indistinct lobation.

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Figured Specimen (USNM 331101; Pl. 10, figs. 3, 4) | 1.11 | 0.6 |
| Figured Specimen (USNM 331102; Pl. 10, figs. 5, 6) | 1.13 | 0.6 |
| Figured Specimen (USNM 331105; Pl. 11, fig. 5) | 0.8 | 0.42 |
| Figured Specimen (USNM 331106; Pl. 11, fig. 6) | 1.14 | 0.41 |

*Geographic distribution.*—

West Virginia: Kanawha County, USGS collns. 12910-PC (USNM 331101), 12917-PC (USNM 331102).

Kentucky: Butler County, USGS colln. 12974-PC (USNM 331105); Leslie County, USGS collns. 12926-PC (USNM 331106), 12923-PC (168212).

*Geologic age.*—Middle Pennsylvanian (Atokan).

Genus **KIRKBYA** Jones *in* Kirkby, 1859 [1860]

*Discussion.*—See Sohn (1954, p. 9) for a discussion of this genus. Because some Late Pennsylvanian specimens of "*Kirkbya*" under study have an aggregate adductor muscle-scar pattern instead of the diagnostic "kirkbyan" pit, this genus may be revised. Although species in *Kirkbya* s.l. have not been as yet recovered in surface collections of the Winifrede Limestone of Hennen (1914), rare and mostly fragmented specimens have been found in borehole cores. The occurrences of such specimens are indicated in Table 1 as Kirkbyidae indet. A unique, albeit broken, identifiable left valve from a borehole core is discussed below.

*Geologic range.*—Mississippian to Permian.

**Kirkbya magna** Roth *sensu* Cooper, 1946
Plate 10, figures 10, 11

*Kirkbya magnum* [*sic*] Roth, 1929, p. 16, pl. 1, figs. 2a, b [Wapanucka Limestone, Pontotoc County, Oklahoma].
*Kirkbya magna* Roth. Cooper, 1946, p. 105, pl. 16, fig. 25 [Shale between "Seville Limestone" beds (Atokan), Mercer County, Illinois]; Shaver and Smith, 1974, p. 31, pl. 3, figs. 14, 15 ["Lead Creek Limestone Member" of Tradewater Formation, Hancock County, Kentucky].

*Discussion.* The specimens illustrated by Cooper (1946) and by Shaver and Smith (1974) may not be conspecific with Roth's species. Roth's holotype is on a slide (USNM 80181) that contains the two illustrated specimens and two additional fragments of valves. The original of his figure 2a, the holotype, does not have any ". . . bifurcating costae running over the carapace" (Roth, 1929, p. 17). The original of Roth's figure 2b and a second broken left valve do have thin costae as described by Roth (p. 17), but these are not as pronounced as costae on the specimen illustrated herein and those illustrated by Cooper and by Shaver and Smith. Shaver and Smith's specimen (1974, pl. 3, fig. 15; IU 11622) has a greatest length of 1.7 mm and has the same strong costae illustrated herein on a smaller valve (Pl. 10, fig. 11).

*Measurements (in mm).—*

| | greatest length | greatest height |
|---|---|---|
| Figured Specimen (USNM 331107; Pl. 10, figs. 10, 11) | 0.9+ | 0.5 |

*Geographic distribution.—*

West Virginia: Kanawha County, USGS colln. 25660-PC (USNM 331107).

Illinois: Mercer County.

Kentucky: Leslie County, USGS colln. 12923-PC (USNM 168218).

?Oklahoma: Pontotoc County.

*Geologic age.*—Early Pennsylvanian(?), Middle Pennsylvanian.

Suborder unknown

Superfamily **DREPANELLACEA** Ulrich and Bassler, 1923

Family **KIRKBYELLIDAE** Sohn, 1961

*Discussion.*—This family was described as new both in Moore (1961, p. Q131) and in Sohn (1961, p. 142). Because Sohn (1961) was published in 1962, the original reference is "Sohn *in* Moore (1961)."

*Geologic range.*—Silurian through Pennsylvanian.

Genus **KIRKBYELLA** Coryell and Booth, 1933

Subgenus **BERDANELLA** Sohn, 1961

*Kirkbyella* (*Berdanella*) Sohn, 1961, p. 145.

*Type-species.—Kirkbyella perplexa* Wilson, 1935. Birdsong Shale (Lower Devonian), Tennessee.

*Discussion.*—When I described this subgenus I noted that the specimen illustrated by Cooper (1946, p. 106, pl. 17, fig. 9) as *Kirkbyella* cf. *K. gutkei* Croneis and Bristol, 1939, from the "Fulda Limestone" (Lower Pennsylvanian), Indiana, does not belong to that species, but I inadvertently recorded the range of the subgenus as Silurian to Upper Mississippian. Omara and Gramann (1966, p. 150, pl. 1, fig. 5) illustrated a specimen from the Upper Carboniferous (upper Missourian-lower Virgilian) in the Eastern Desert of Egypt as *Kirkbyella* (*Berdanella*) sp.

*Geologic range.*—Silurian through Pennsylvanian.

**Kirkbyella (Berdanella) ricei** new species
Plate 10, figures 1, 2; Plate 11, figures 21, 22

?*Kirkbyella* cf. *K. gutkei* Croneis and Bristol. Marple, 1952, p. 935, pl. 134, fig. 23 ["Poverty Run Limestone," Muskingum County, Ohio].

*Etymology of name.*—In honor of Charles L. Rice, U.S. Geological Survey, who collected ostracode samples in Kentucky.

*Holotype.*—USNM 331108.

*Paratypes.*—USNM 331109, 331110, 331614.

*Type-locality.*—Shale above Hindman coal, USGS colln. 12927-PC.

*Other localities.*—USGS collns. 25644-PC, 25669-PC.

*Diagnosis.*—Differs from *Kirkbyella* (*Berdanella*) *gutkei* (Croneis and Bristol, 1939) in that the reticulations are not arranged in horizontal lines parallel to the dorsal margin, and the ventral lobe does not extend upwards to approximate midheight.

*Description.*—The carapace is quadrate in lateral outline. The subrectangular reticulations cover the entire surface of the valves.

*Discussion.*—Marple illustrated a poorly preserved specimen that is crushed, but does have subrectangular reticulations. The Morrowan specimen illustrated by Cooper (1946, pl. 17, fig. 9) is poorly preserved and has a sharp border along the ventral margin of the horizontal lobe that may represent the edge of the broken valve. The round reticulations indicate that it does not belong to the new species.

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Paratype (USNM 331614; Pl. 10, figs. 1, 2) | 0.56 | 0.31 |
| Holotype (USNM 331108; Pl. 11, figs. 21, 22) | 0.53 | 0.3 |
| Unfigured Paratypes (USNM 331109, 331110) | 0.55–0.61 | 0.3–0.32 |

*Geographic distribution.*—

West Virginia: Kanawha County, USGS collns. 25644-PC (USNM 331110), 25669-PC (USNM 331109, 331614).

Kentucky: Leslie County, USGS colln. 12927-PC (USNM 331108).

?Ohio: Muskingum County.

*Geologic age.*—Middle Pennsylvanian (Atokan).

## Superfamily **YOUNGIELLACEA** Kellett, 1933

## Family **YOUNGIELLIDAE** Kellett, 1933

### Genus **MOORITES** Coryell and Billings, 1932

*Moorites* Coryell and Billings, 1932, p. 182; Sohn *in* Moore, 1961, p. Q178.

*Type-species.*—*Moorites hewetti* Coryell and Billings, 1932, p. 182, pl. 18, fig. 5 [= *Glyptopleurina*? *minuta* Warthin, 1930, Wayland Shale (Member of Graham Formation), Eastland County, Texas].

*Diagnosis.*—Youngiellidae with smooth rims along end margins, surface reticulated, with or without curved, intersecting smooth costae.

*Discussion.*—The above diagnosis differs from the original as well as the one in Moore (1961) because specimens without distinct costae on the valve surface are referred herein to *Moorites* (Pl. 11, figs. 2–4). Prof. H. N. Coryell donated to me topotype specimens of the faunule described by Coryell and Billings (1932). Two of those topotypes were illustrated in Moore (1961, figs. 115, 3a–d) as *Moorites minutus* (Warthin, 1930). Both topotypes are carapaces; the first is USNM 119562 (figs. 115, 3a–c), and the second carapace, which was converted to fluorite (USNM 119561; fig. 115, 3d), shows in transmitted light the taxodont hinge of the Youngiellidae. The shells of this genus are usually thin, fragile, and subject to crushing (Pl. 10, figs. 8, 9); consequently, identification of species within this taxon is difficult. Cooper (1946, p. 122, pl. 21, figs. 14, 15) illustrated the inside of two valves that do not have taxodont hingements, but this lack of hingements may be due to poor preservation.

*Geologic range.*—Devonian through Pennsylvanian.

### **Moorites minutus** (Warthin, 1930)?
Plate 10, figures 8, 9

*Glyptopleurina*? *minuta* Warthin, 1930, p. 67, pl. 5, figs. 6a, b [Holdenville Shale, Pontotoc County, Oklahoma].

*Moorites minutus* (Warthin). Coryell and Billings, 1932, p. 183, pl. 18, fig. 6 [Wayland Shale (Member of Graham Formation), Eastland County, Texas]; Sohn *in* Moore, 1961, p. Q178, fig. 115, 3a–f; Cooper, 1946, p. 122, pl. 21, figs. 11–17 ["Centralia" limestone (Missourian), Montgomery County, Illinois (see for synonymy)]; Marple, 1952, p. 938, pl. 135, figs. 22, ?23 ["Lower Mercer Limestone," Muskingum County, Ohio].

*Moorites hewetti* Coryell and Billings, 1932, p. 182, pl. 18, fig. 5 [Wayland Shale (Member of Graham Formation), Eastland County, Texas].

*Discussion.*—As stated under the genus, species based on inadequate material may have been misidentified. This is the reason for questioning my identification.

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Figured Specimen (USNM 331111; Pl. 10, figs. 8, 9) | 0.5 | 0.3 |
| Unfigured Specimen (USNM 331112) | 0.4 | 0.22 |

*Geographic distribution.*—

West Virginia: Kanawha County, USGS collns. 25656-PC (USNM 331111), 25659-PC (USNM 331112).

Illinois: Montgomery County.

Ohio: Muskingum County.

Oklahoma: Pontotoc County.

Texas: Eastland County.

*Geologic age.*—Middle and Late Pennsylvanian.

### **Moorites** spp.
Plate 11, figures 2–4

*Discussion.*—The illustrated specimens and a carapace from a borehole core in West Virginia, and a right valve from Leslie County, Kentucky, do not show the diagnostic taxodont hinge; consequently, they are tentatively referred to the genus in open nomenclature. The specimen from West Virginia (USNM 168224) resembles the one illustrated on Plate 11 as figure 2.

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Figured Specimen (USNM 331103; Pl. 11, fig. 2) | 0.45 | 0.22 |
| Figured Specimen (USNM 331104; Pl. 11, figs. 3, 4) | 0.49 | 0.23 |
| Unfigured Specimen (USNM 168213) | 0.45 | 0.25 |
| Unfigured Specimen (USNM 168224) | 0.48 | 0.24 |

*Geographic distribution.*—

West Virginia: Kanawha County, USGS colln. 25664-PC (USNM 168224).

Kentucky: Knott County, USGS colln. 12920-PC (USNM 331104); Leslie County, USGS collns. 12927-PC (USNM 331103), 12923-PC (USNM 168213).

*Geologic age.*—Middle Pennsylvanian (Atokan).

?Order **PALAEOCOPIDA** Henningsmoen, 1953

Suborder Unknown

Superfamily **PSEUDOPARAPARCHITACEA** new superfamily

*Diagnosis.*—Small, as much as one mm in greatest length; straight-backed; symmetrical, essentially equivalved; nonsulcate, with or rarely without strong to weak dorsoposterior spine. Hinge simple, with or without tongue and groove; without calcified inner lamella, adductor muscle-scar pattern unknown. Possibly dimorphic in width of posterior or in lateral outline.

*Discussion.*—Sohn (1971, p. A5) followed Scott (*in* Moore, 1961, p. Q194) and included *Pseudoparaparchites* Kellett, 1933, in the Paraparchitacea Scott, 1959. The present study indicates that *Microparaparchites* Croneis and Gale, 1939, considered by Scott (*in* Moore, 1961) to be a synonym of *Pseudoparaparchites*, is a valid genus. Both the above-mentioned genera form a distinct unit of marine palaeocopid? ostracodes, whereas the Paraparchitacea belong to the Podocopida.

*Geologic range.*—Devonian(?), Mississippian through Permian.

Family **PSEUDOPARAPARCHITIDAE** new family

*Discussion.*—This family differs from the Aparchitidae Jones *in* Chapman, 1901, in lacking velar structures. Polenova (*in* Chernysheva, 1960, p. 294) referred *Pseudoparaparchites* Kellett, 1933, to the Aparchitidae. The following genera are presently referred to the new family Pseudoparaparchitidae: *Pseudoparaparchites* Kellett, 1933, *Microparaparchites* Croneis and Gale, 1939, and possibly an as-yet-undescribed genus referred to herein as "*Microparaparchites*."

*Geologic range.*—Devonian?, Mississippian through Permian.

Genus **PSEUDOPARAPARCHITES** Kellett, 1933

*Pseudoparaparchites* Kellett, 1933, p. 67.

*Type-species.*—*Pseudoparaparchites kansensis* Kellett, 1933, p. 68, pl. 13, fig. 17 [shale in "Elmdale Formation" (Upper Pennsylvanian), Chase County, Kansas].

*Discussion.*—See Discussion under the family Pseudoparaparchitidae.

*Geologic range.*—Devonian(?), Mississippian through Permian.

**Pseudoparaparchites** spp.

Plate 3, figures 16, 17; Plate 11, figures 17, 18

A carapace of *Pseudoparaparchites* from a borehole core in the Winifrede Limestone of Hennen (1914) (USGS colln. 25656-PC) in West Virginia and a fragment of a right valve from Kentucky (USGS colln. 12920-PC) that shows an exceptionally long dorsoposterior spine are illustrated to demonstrate the difference between this genus and "*Microparaparchites*" *reductospinosus* n. sp. Note the robust base of the spine relative to the size of the valve (shown in Pl. 3, figs. 16, 17) as compared to the spine on "*Microparaparchites*" (Pl. 3, figs. 1, 2, 12, 14, 18). Compare the dorsal trend of the spine on the exfoliated right valve (Pl. 11, figs. 17, 18) with the trend on "*Microparaparchites*" (shown on Pl. 11, figs. 14–16).

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Figured Specimen (USNM 325042; Pl. 3, figs. 16, 17) | 0.50 | 0.35 |
| Figured Specimen (USNM 168222; Pl. 11, figs. 17, 18) | 0.48+ | 0.2+ |

*Geographic distribution.*—

West Virginia: Kanawha County, USGS collns. 25656-PC (USNM 325042), ?12917-PC.

Kentucky: Knott County, USGS colln. 12920-PC (USNM 168222).

*Geologic age.*—Middle Pennsylvanian (Atokan).

Genus **MICROPARAPARCHITES** Croneis and Gale, 1939

*Microparaparchites* Croneis and Gale, 1939, p. 256.

*Type-species.*—*M. spinosus* Croneis and Gale, 1939, p. 256, pl. 6, figs. 30, 31 [Golconda Formation (Upper Mississippian), Pope County, Illinois].

*Discussion.*—A study in progress suggests that the species in the Winifrede Limestone of Hennen (1914) may represent a distinct genus; consequently, it is designated herein as "*Microparaparchites*."

*Geologic range.*—Devonian(?), Mississippian through Permian.

"**Microparaparchites**" **reductospinosus** new species
Plate 3, figures 1–15, 18–25; Plate 11,
figures 14–16, 19, 20

*Etymology of name.*—Derived from reduction in size of posterodorsal spine during ontogeny.

*Holotype.*—USNM 325043.

*Paratypes.*—USNM 325044 through 325052.

*Type-locality.*—Harewood section, Fayette County, West Virginia, USGS colln. 12971-PC.

*Other localities.*—

West Virginia: Fayette County, USGS colln. 25727-PC (USNM 325053); Kanawha County, USGS collns. 26774-PC (USNM 325045, 325049), 25690-PC (USNM 325047).

Kentucky: Leslie County, "Magoffin beds" (Atokan), USGS collns. 21413-PC (USNM 325055, 168221), 12923-PC (USNM 168211); Pike County, top of "Kendrick shale" (Morrowan), USGS colln. 21604-PC (USNM 325056); Knott County, USGS colln. 12920-PC (USNM 325166).

*Diagnosis.*—Nonpunctate; posterior margin larger than anterior in adults, smaller in young instars, progressively larger with growth; spine small in adults, closer to dorsal margin than posterior margin, located on elongated swelling tapering toward the front in adults, swelling decreases in young instars, increases with growth; greatest height in posterior quarter in adults, at or in front of midlength in younger growth stages. Dorsal outline resembles truncated wedge; anterior as blunt as or blunter than posterior depending on growth stage; greatest width in dorsal outline near spine or in front of midlength depending on growth stage, posterior outline at or below spine depending on growth stage.

*Description.*—The dorsal margin is straight, the anterior cardinal angle is wider than the posterior cardinal angle, which is more than 90°. The anterior margin is rounded and has the greatest convexity at or below midheight, depending on the growth stage; the posterior margin is also rounded, its greatest convexity is at or above midheight (compare Pl. 3, figs. 2, 15 with figs. 19, 23). The ventral margin is more convex in young growth stages (Pl. 3, figs. 2, 6, 8) than in later ones; the greatest height is at or in front of midlength, becoming less convex with growth and having the greatest height behind midlength (Pl. 3, figs. 4, 12, 19, 21, 23). The dorsoposterior spine has a relatively narrow base, is short and pointed in young instars (Pl. 3, figs. 1, 8, 12), becomes progressively smaller with growth, and practically disappears in adults (Pl. 3, figs. 19, 21, 23). This spine is located, in adults, on a horizontal subdued swelling that tapers toward the anterior (Pl. 3, figs. 19, 23); this swelling is progressively more subdued on smaller growth stages (Pl. 3, figs. 1, 3, 7, 13, 11, 21). The surface is smooth. The left valve narrowly overlaps the right along all margins (Pl. 3, figs. 1, 7, 11, 20, 22, 24, 25).

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Paratype (USNM 325046; Pl. 3, figs. 6–8) | 0.52 | 0.38 |
| Paratype (USNM 325044; Pl. 3, figs. 1, 2) | 0.55 | 0.35 |
| Paratype (USNM 325048; Pl. 3, figs. 11, 12) | 0.62 | 0.45 |
| Paratype (USNM 325045; Pl. 3, figs. 3–5) | 0.68 | 0.48 |
| Paratype (USNM 325047; Pl. 3, figs. 9, 10) | 0.7 | 0.45 |
| Paratype (USNM 325049; Pl. 3, figs. 13–15) | 0.72 | 0.50 |
| Paratype (USNM 325051; Pl. 3, figs. 20–22) | 0.73 | 0.65 |
| Paratype (USNM 325050; Pl. 3, figs. 18, 19) | 0.8 | 0.60 |
| Holotype (USNM 325043; Pl. 3, fig. 23) | 0.91 | 0.60 |
| Paratype (USNM 325052; Pl. 3, figs. 24, 25) | 0.95 | 0.65 |
| Figured Specimen (USNM 325055; Pl. 11, figs. 14–16) | 0.62 | 0.43 |
| Figured Specimen (USNM 168221; Pl. 11, figs. 19, 20) | 0.62 | 0.40 |

*Discussion.*—The hinge and overlap of this species are very weak as shown by the polished surface (Pl. 3, figs. 24, 25) located in front of midlength looking towards the anterior of probably a subadult carapace whose greatest length is 0.80 mm. In addition to proving the absence of a calcified inner lamella that removes "*Microparaparchites*" from the Superfamily Paraparchitacea (Pl. 3, figs. 5, 15), the cross-section indicates that the group lacks morphologic structures that would firmly attach the two valves of the carapace as a defense against predators and high-energy turbulence. The hinge structure is weak, and the left valve overreaches the right in this part of the carapace without any interlocking for strength. The ventral overlap of the right valve also is weak at this part of the carapace; there is a very shallow indentation into which the left valve fits. The weak hinge and structure of the carapace suggest a low-energy environment, as postulated by Rice and others (1979, p. F19) for the Magoffin Member of of the Breathitt Formation in Kentucky, where this species is also present (Pl. 11, figs. 14–16, 19–20).

The holotype of *Microparaparchites spinosus* Croneis and Gale, 1939, the type-species, is punctate and has other characters that differ from the new species. Because a revision of that genus is beyond the scope of this paper, I am referring the species to "*Microparaparchites*". *Paraparchites latidorsatus* Warthin, 1930, based on a carapace 0.57 mm long from the Wewoka Formation (Des Moinesian) of Oklahoma, is congeneric with the new species.

*Geographic distribution.*—See above, other localities.

*Geologic age.*—Early and Middle Pennsylvanian (Morrowan and Atokan).

Order Unknown

Superfamily Unknown

Family **SANSABELLIDAE** Sohn, 1961

*Discussion.*—Polished surfaces and thin sections of *Sansabella* made during the preparation of the American Treatise (Sohn, *in* Moore, 1961) did not disclose any calcified inner lamella (duplicature); consequently, the family was placed in the Kloedenellocopina Scott, 1961, Kloedenellacea Scott, 1961. At that time, I questioned the placement of Geisinidae in this superfamily (Sohn, *in* Moore, 1961, p. Q182), because of the presence of a duplicature in *Geisina* Johnson, 1936. Pyritized valves of *Sansabella* Roundy, 1926, however, do have a duplicature; consequently, I now suspect that the Sansabellidae may be of polyphyletic origin and include some taxa with duplicatures and others without duplicatures. Because this problem is not within the scope of this paper, I am classifying this family in Order and Superfamily Unknown.

Genus **SANSABELLA** Roundy, 1926

*Sansabella* Roundy, 1926, p. 5.

*Type-species.*—*Sansabella amplectans* Roundy, 1926, p. 6, pl. 1, figs. 3a–5 [Marble Falls Limestone, San Saba County, Texas].

*Discussion.*—Coryell and Sohn (1938) proposed the Late Mississippian genus *Persansabella* because the hingement and overlap of the type-species *P. bradfieldi* Coryell and Sohn, 1938, was the reverse of that of *Sansabella*. Later I recognized (Sohn, *in* Moore, 1961, p. Q187) that specimens of *Sansabella* exhibit reversal of hingement and overlap in most collections and therefore designated *Persansabella* Coryell and Sohn, 1938, a synonym of *Sansabella*. The muscle-scar pattern is aggregate (Sohn, 1965, p. B70).

*Geologic range.*—Mississippian through Permian.

**Sansabella stewartae** Marple, 1952

Plate 4, figures 19–23

*Sansabella stewartae* Marple, 1952, p. 936, pl. 135, figs. 9–16, 18 (not fig. 17 = gen. indet.) ["Lower Mercer Limestone" (upper Atokan), Perry County, Ohio].*

*Discussion.*—The lateral outline, size range, and shallow to nonexistent subcentral pit identify this species. Two topotypes, a carapace and a right valve from the "Lower Mercer Limestone," Marple's locality 2 (USNM 325060) are identical with the West Virginia specimens. The spinelets along the end margins (Pl. 4, figs. 20, 21, 23) are not diagnostic of this species. Specimens having similar spinelets are identified as *Sansabella laevis* (Warthin, 1930) in collections from the "Devils Kitchen Member" of the Deese Formation (lower Des Moinesian) in Love County, Oklahoma, USGS colln. 12845-PC (USNM 325059). In addition to the illustrated specimens, I have more than 75 specimens from the type-locality of the Winifrede Limestone of Hennen (1914) (USNM 325063) on most of which the spinelets are not preserved. The shape, size, and virtual absence of a subcentral pit indicate that they are conspecific.

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Figured Specimen (USNM 325057; Pl. 4, figs. 19–21) | 0.74 | 0.50 |
| Figured Specimen (USNM 325058; Pl. 4, figs. 22, 23) | 0.74 | 0.50 |
| Unfigured Specimen (USNM 325062) | 0.82 | 0.53 |

*Geographic distribution.*—

West Virginia: Kanawha County, USGS collns. 26774-PC (USNM 325057, 325058), 25664-PC (USNM 325061).

Kentucky: Knott County, USGS colln. 12920-PC (USNM 325054).

Ohio: Perry County.

*Geologic age.*—Middle Pennsylvanian (Atokan, Des Moinesian).

Order **PODOCOPIDA** Sars, 1866

Suborder **PARAPARCHITOCOPA** Gramm, 1975

Gramm (*in* Gramm and Ivanov, 1975, p. 551) diagnosed this suborder to include the superfamily Paraparchitacea Scott, 1959, as well as the nominate family Paraparchitidae Scott, 1959. He based his diagnosis on the adductor-muscle-attachment scar pattern of *Paraparchites minax* Ivanov *in* Gramm and Ivanov, 1975, but noted (Gramm and Ivanov, 1975, p. 556) that three types of scar patterns may be involved.

Superfamily **PARAPARCHITACEA** Scott, 1959

See discussion by Gramm and Ivanov (1975).

?Family **PARAPARCHITIDAE** Scott, 1959

Because of the possible inclusion of three types of muscle-scar patterns, future study may disclose that more than one family is involved and that the genus *Shishaella* Sohn, 1971, may warrant a separate family designation.

* Marple (1957, p. 84) designated a lectotype.

### Genus **SHISHAELLA** Sohn, 1971

*Type-species.—Paraparchites nicklesi* var. *cyclopea* Girty, 1910.

*Discussion.*—This genus is distinguished from other paraparchitid genera by the presence of a single spine on the posterodorsal area of the overlapped valve. Some of the species in this genus have been used in correlation and in age determination (Sohn and Jones, *in press,* Fig. 2). The presence of a dorsoposterior spine suggests that this group probably did not burrow in the substrate; however, there is no evidence that species in this group could swim.

*Geologic range.*—Mississippian through Permian.

#### **Shishaella saundersi** new species

Plate 1, figures 8–17, 20–26; Plate 5, figures 24–29

*Etymology of name.*—In honor of Harold I. Saunders, U.S. Geological Survey.

*Holotype.*—USNM 325069.

*Paratypes.*—USNM 325070 through 325079.

*Type-locality.*—Harewood section, Fayette County, West Virginia, USGS colln. 12971-PC.

*Diagnosis.*—Greatest height at approximately anterior third of greatest length; anterior margin lower than posterior margin; distance of dorsoposterior spine from hinge margin about half the distance from posterior margin.

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Paratype (USNM 325074; Pl. 1, figs. 20, 21) | 0.65 | 0.50 |
| Paratype (USNM 325075; Pl. 1, figs. 22–24) | 0.69 | 0.50 |
| Paratype (USNM 325072; Pl. 1, figs. 13, 14) | 0.69 | 0.50 |
| Paratypes (USNM 325073; Pl. 1, fig. 17) | 0.85 | 0.60 |
| Paratypes (USNM 325076; Pl. 1, figs. 25, 26) | 1.05 | 0.80 |
| Paratype (USNM 325071; Pl. 1, figs. 11, 12) | 1.10 | 0.80 |
| Paratype (USNM 325070; Pl. 1, figs. 8–10) | 1.30 | 0.92 |
| Holotype (USNM 325069; Pl. 1, figs. 15, 16; Pl. 5, figs. 24, 25) | 1.30 | 1.0 |
| Paratype (USNM 325077; Pl. 5, figs. 26–29) | 1.70 | 1.20 |
| Eleven Unfigured Paratypes (USNM 325079) | 0.62–1.75 | 0.48–1+ |

*Discussion.*—Plate 1, figures 9, 10, 11, 12, 15, 16, 20, 21, 25 and 26 and Plate 5, figures 24 and 25 are all at the same magnification. The young instar illustrated by Plate 1, figures 20–21 is about half the size of the holotype (Pl. 1, figs. 15, 16), from which it differs considerably in lateral outline and in having a smooth curvature on the right valve near the hinge; on the holotype this area is bulged. The features typical of the specimen illustrated by Plate 1, figures 15 and 16 are seen also on other growth stages (compare Pl. 1, figs. 11, 12; 13, 14; 22–24 with figs. 8, 9; 17, 25, 26). Figures 8–10 represent a carapace on which the left valve is missing and the internal cast of that valve is shown. Plate 1, figure 10 shows the hinge of the smaller right valve as well as the muscle-scar impression that resembles those illustrated for *Shishaella cyclopea* (Girty, 1910) by Sohn (1971, pl. 7).

This species differs from *S. cyclopea* in that the bulge near the hinge of the right valve is not as strong, does not have an indentation or crease below it, and thins toward the anterior, resulting in a slight concavity near the anterior in lateral profile (see Pl. 1, figs. 16, 26). The base of the posterodorsal spine is not as robust as that in the Mississippian type-species.

*Geographic distribution.*—Known only from the type-locality.

*Geologic age.*—Middle Pennsylvanian (Atokan).

### Suborder Unknown

### Superfamily Unknown

### Family **GEISINIDAE** Sohn, 1961

Although this family was classified by Moore (1961, p. Q182) in the Palaeocopida, Kloedenellocopina, Kloedenellacea, he noted my opinion that this family belongs in the Podocopida.

### Genus **PLAVSKELLA** Samoilova, 1951

*Plavskella* Samoilova, 1951, p. 169.

*Type-species.—Plavskella famensis* Samoilova, 1951, p. 169, figs. 10–13 [Upper Devonian, Russian Platform].

*Discussion.*—Sohn (*in* Moore, 1961, p. Q184) had considered the then monotypic genus *Plavskella* to be a junior subjective synonym of *Hypotetragona* Morey, 1935 in the Geisinidae. Since then Chizhova (1963, 1967, 1977) described two additional Late Devonian species: *Plavskella tschekmaguschica* Chizhova, 1963, and *P. volgogradensis* Chizhova, 1977. The presence of an additional species, *P. englundi* n. sp., in the Winifrede Limestone of Hennen (1914) indicates that *Plavskella* is a valid genus. *Plavskella* differs from *Hypotetragona* in lacking reticulations along the dorsal and free margins as illustrated for the latter by Kesling and Chilman (1978, pp. 81–83, pls. 58, 59, 60, 107).

Samoilova (1951, p. 172) compared the type-species, *P. famensis,* with the Late Mississippian *Neokloedenella prima* Croneis and Funkhouser, 1939, and also with *Jonesina craterigera* (Brady) *fide* Cooper, 1941, p. 56. *Neokloedenella* Croneis and Funkhouser, 1939, differs from *Plavskella* in lacking a dorsoanterior node and in having a nonreticulated surface. However, the absence of reticulations on Paleozoic ostracodes in this group may be due to faulty preservation as shown herein on Plate 4, figure 6. *Jonesina* Ulrich and Bass-

ler, 1908, as based on the type-species, *Beyrichia fastigiata* (Jones and Kirkby, 1867) is trinodose in the males, is binodose with an inflated posterior in the females, and has spinose or frilled free margins as shown by Robinson (1978, pl. 4, figs. 2a, b).

Species that probably should be referred to *Plavskella* are *Geisina jollifina* Cooper, 1946, and *Jonesina deesensis* Bradfield *sensu* Cooper, 1946, as well as some of the other species referred to *Jonesina,* and *Adelphobolbina*? *cristinae* Bless, 1967. The fact that neither the adductor-muscle-scar pattern nor the type of duplicature is known in all the above taxa does not permit positive referral to *Plavskella*. *Quasigeisina* Rome, 1973, from the Tournaisian (Lower Carboniferous) of Europe differs from *Plavskella* in the overlap along the dorsum and in that the anterior node is separated from the subcentral sulcus.

*Geologic range.*—Upper Devonian through Middle Pennsylvanian.

**Plavskella englundi** new species
Plate 4, figures 1–18

*Jonesina arcuata* (Bean). Bradfield, 1935, p. 34, pl. 2, figs. 6, 7 [Morrowan, Carter County, Oklahoma].

*Etymology of name.*—In honor of Kenneth J. Englund, U.S. Geological Survey.

*Holotype.*—USNM 325080.

*Paratypes.*—USNM 325081 through 325086, 325093.

*Type-locality.*—Harewood section, Fayette County, West Virginia, USGS colln. 12971-PC.

*Other localities.*—

West Virginia: Kanawha County, type-locality of Winifrede Limestone of Hennen (1914), USGS collns. 26713-PC (USNM 325087), 26774-PC (USNM 325085, 325088), 25656-PC (USNM 325089), 25664-PC (USNM 325095), 25665-PC (USNM 325090), 25668-PC (USNM 325094); Fayette County, USGS colln. 25727-PC (USNM 325092).

Kentucky: Pike County, top of "Kendrick shale" (Morrowan), USGS colln. 21604-PC (USNM 325091); Leslie County, "Magoffin beds" (Atokan), USGS colln. 21413-PC (USNM 168208); Knott County, USGS colln. 12920-PC.

*Diagnosis.*—Differs from all other species referable to this genus in having nonreticulated margins.

*Description.*—Surface reticulated, except along dorsal and free margins. A wide and deep vertical sulcus trends downward from the dorsal margin to or above midheight in front of midlength, the sulcus widens at the base and trends forward to outline a distinct node that is bounded in front by the pinching of the valve surface near the anterior cardinal angle. The free margins and the dorsal margin including the stragulum are not reticulated. Although there is a sharp bend between the lateral surface and the ventral surface (Pl. 4, figs. 3, 9, 10, 13), the boundary is smooth and without a rim or ridge (Pl. 4, figs. 5, 9, 11, 14, 17, 18). Plate 4, figure 18 shows in detail that reticulations terminate without any distinct ridge. Younger growth stages (Pl. 4, figs. 2, 4, 16) are more truncated in the ventroposterior than mature and subadult stages. Because young stages (Pl. 4, figs. 1, 6, 16) have a narrow posterior in dorsal outline, I infer that adults having wide posteriors are females.

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Paratype (USNM 325081; Pl. 4, figs. 1–3) | 0.5 | 0.31 |
| Paratype (USNM 325082; Pl. 4, figs. 4, 5) | 0.65 | 0.41 |
| Paratype (USNM 325083; Pl. 4, fig. 6) | 0.63 | 0.34 |
| Holotype (USNM 325080; Pl. 4, figs. 7–9) | 0.73 | 0.51 |
| Paratype (USNM 325084; Pl. 4, figs. 10–14) | 0.7 | 0.42 |
| Paratype (USNM 325085; Pl. 4, figs. 15, 16) | 0.6 | 0.39 |
| Paratype (USNM 325086; Pl. 4, figs. 17, 18) | 0.7 | 0.4 |
| Twenty Unfigured Paratypes (USNM 325093) | 0.5–0.75 | 0.3–0.46 |

*Discussion.*—This species differs from *Geisina jollifina* Cooper, 1946 (= ?*Plavskella*) in having larger polygonal reticulations and in lacking the marginal flange. The shell is thin and fragile; consequently, many valves have breaks in them (Pl. 4, figs. 15, 16). This fragility is probably the reason that all the single valves recovered are filled with matrix and may break during unsuccessful removal of the filling undertaken to discern the hinge and marginal structures.

Although Bradfield's (1935) types are at Indiana University, he donated to me his collection of duplicate specimens. Among them was a left valve, probably of a male, 0.80 mm long, from his locality 160, about 61 m (200 ft) below the Otterville Limestone (upper Morrowan) in Carter County, Oklahoma, that he had identified as *Jonesina arcuata* (Bean). This specimen, lost during examination for this study, had a calcified inner lamella. One of three specimens in USGS colln. 21604-PC (USNM 325091) also has a calcified inner lamella. Because of this structure, I am placing *Plavskella* in the Geisinidae, Podocopida.

The relatively small size and overall similarity of this species to certain interstitial subterranean nonmarine ostracodes of post-Paleozoic age (Danielopol, 1980), coupled with the fact that the Winifrede Limestone of Hennen (1914) is a shallow marine tongue in continental deposits, suggest that this group may have been one of the ancestors of certain post-Paleozoic subterranean nonmarine ostracodes.

*Geographic distribution.*—Oklahoma and other localities (see above).

*Geologic age.*—Early and Middle Pennsylvanian (Morrowan and Atokan).

Suborder **BAIRDIOCOPINA** Gründel, 1967

Superfamily **BAIRDIACEA** Sars, 1888

*Geologic range.*—Paleozoic through Holocene.

Family **BAIRDIIDAE** Sars, 1888

*Discussion.*—The Winifrede Limestone of Hennen (1914) contains one species each in *Bairdia* McCoy, 1844, *Bairdiolites* Croneis and Gale, 1939, *Orthobairdia* Sohn, 1960, and *Bairdiacypris* Bradfield, 1935, as well as unidentifiable molds and fragments belonging to the above genera.

*Geologic range.*—Paleozoic through Holocene.

Genus **BAIRDIA** McCoy, 1844

*Discussion.*—See Sohn (1960) for the synonymy and discussion of this genus. Collections from exposures of the Winifrede Limestone of Hennen (1914) contain fragments of this genus that probably belong to several species but are inadequately preserved for identification. Only the one species identified below is represented at the Harewood section by crushed carapaces. Because an excellently preserved carapace of this species was found in a borehole core, that carapace is illustrated herein.

*Geologic range.*—Paleozoic through Holocene.

**Bairdia isoscelata** Shaver, 1959
Plate 5, figures 19, 20

*Bairdia isoscelata* Shaver *in* Thompson, Shaver, and Riggs, 1959, p. 785, pl. 107, figs. 28–31, text-fig. 2, figs. 11, 12 [Unnamed limestone, Butler County, Kentucky].

*Discussion.*—The specimens on hand were compared with Shaver's holotype (InGS 244) and four of his paratypes (InGS 245–248). The illustrated specimen (USGS colln. 12917-PC) is much better preserved than Shaver's material, as are the crushed specimens (USGS colln. 12971-PC, USNM 325097). The dorsal outline (Pl. 5, fig. 19) is identical with Shaver's text-figure 2, figure 11, and the lateral outline matches that of the holotype (Shaver, 1959, pl. 107, fig. 29).

In discussing the ostracodes from near Morgantown, Kentucky, Shaver (1959, p. 781) stated that the fauna is more like that from the "Ferdinand Limestone" of Indiana to which Cooper (1946) had assigned an Atokan age.

In addition to the illustrated specimen from a borehole core in Kanawha County, West Virginia, I have three laterally crushed carapaces and a right valve without part of the anterior from the Harewood section, Fayette County, USGS colln. 12971-PC (USNM 325097).

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Figured specimen (USNM 325096; Pl. 5, figs. 19, 20) | 1.4+ | 0.70 |
| Three Unfigured Specimens (USNM 325097) | 1.31 | 0.60 |
| | 1.31 | 0.60 |
| | 1.30 | 0.70 |

Shaver (1959, p. 785) recorded the holotype as 1.50 mm long and 0.66 mm high. My measurements of his specimen are: length 1.44 mm and height 0.65 mm; however, the holotype and the paratypes are badly corroded, and some of the shell is missing.

*Geographic distribution.*—

West Virginia: Fayette County, and Kanawha County.

Kentucky: Butler County; Leslie County (Atokan), USGS colln. 12923-PC (USNM 168215).

*Geologic age.*—Middle Pennsylvanian (Atokan).

Genus **ORTHOBAIRDIA** Sohn, 1960

*Orthobairdia* Sohn, 1960, p. 65.

*Type-species.*—*Bairdia cestriensis* Ulrich, 1891 [Chester shale, Kentucky].

*Discussion.*—See Sohn (1960, p. 65) for diagnosis. Since the genus was described, eleven taxa were assigned to the genus and three taxa were cited as *Bairdia* (*Orthobairdia*). I prefer to consider the taxon as a valid genus.

*Geologic range.*—Middle Devonian through Permian.

**Orthobairdia oklahomaensis** (Harlton, 1927)
Plate 10, figure 7

*Bairdia oklahomaensis* Harlton, 1927, p. 209, pl. 33, figs. 12–21 [upper part of "Glenn Formation," Carter County, Oklahoma]; Shaver, 1960, p. 656.

*Orthobairdia oklahomaensis* Harlton. Sohn, 1960, p. 66 (see for synonymy and discussion).

*Discussion.*—This common Middle and Late Pennsylvanian species has not been recovered from surface collections in West Virginia; its occurrences in borehole cores in that state are given in Table 1.

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Figured Specimen (USNM 331113; Pl. 10, fig. 7) | 1.2 | 0.7 |

*Geographic distribution.*—

West Virginia: Kanawha County, USGS colln. 25669-PC (USNM 331113).

Kentucky: Leslie County, USGS colln. 12923-PC (USNM 168216).

For other localities see Sohn (1960, p. 66); Shaver (1960, pp. 657–659).

*Geologic age.*—Middle and Late Pennsylvanian (Atokan through Virgilian).

Genus **BAIRDIOLITES** Croneis and Gale, 1939

*Bairdiolites* Croneis and Gale, 1939, p. 288; Sohn, 1960, p. 70.

*Discussion.*—Sohn (1960) constructed a key for 13 species and two in open nomenclature. Since that time two additional species have been described: *B. conifer* Buschmina, 1975 (lower Tournaisian), and *B. brevicostatus* Buschmina, 1970 ("Tiksinian Suite," Upper Pennsylvanian). Internal features are unknown except for one left valve described below.

*Geologic range.*—Lower Mississippian through Upper Pennsylvanian.

**Bairdiolites astigmaticus** new species
Plate 7, figures 14–29

*Etymology of name.*—So named because the lateral ridges point in different directions.

*Holotype.*—USNM 325098.

*Paratypes.*—USNM 325099 through 325102.

*Type-locality.*—Harewood section, Fayette County, West Virginia, USGS colln. 12971-PC.

*Other localities.*—

West Virginia: Kanawha County, USGS collns. 25658-PC (USNM 325103), 25663-PC (USNM 325104).

Kentucky: Pike County, "Kendrick shale" (Morrowan), USGS colln. 21604-PC (USNM 325105).

*Diagnosis.*—Lateral ridges straight, anterior points anteroventrad, posterior points posteroventrad; slight pleat parallel to and below dorsal margin of left valve.

*Description.*—The dorsal outline is subhexagonal and has straight to very gently curved sides; the greatest width is at midlength. In lateral outline, the anterior margin is evenly rounded, and the greatest convexity is at approximate midheight; the posterior margin is bluntly pointed and has the greatest convexity at about the bottom quarter of the greatest height. The hingeline is straight, but the dorsal margin of the left valve is straight to gently convex, the ventral margin is straight. The dorsoposterior margin slopes more sharply than the dorsoanterior margin. The posterior lateral ridge slopes down and back at a greater angle than the dorsoposterior margin; the anterior lateral ridge is straight, is shorter than the posterior ridge, and starts at approximately the same distance from the dorsal margin as the posterior ridge. The left valve has a shallow groove below the dorsal margin that forms an elongated, rounded crest (Pl. 7, figs. 16, 17, 20, 21, 22–24, 26) almost the same length as the hingeline. The dorsoposterior margin of the left valve has, on the inside, a rounded ridge that extends from the posterior to about halfway up the dorsoposterior margin. This structure can be seen on the only left valve (Pl. 7, figs. 28, 29); it does not open to the outside because the left valve overlaps the right in that area. The marginal area is broad (Pl. 7, fig. 29). Other internal features such as the adductor-muscle-scar and detail of hingement are unknown for this or any other species in the genus.

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Paratype (USNM 325099; Pl. 7, figs. 14, 15) | 1.2 | 0.54 |
| Paratype (USNM 325100; Pl. 7, figs. 16–18) | 1.2 | 0.54 |
| Paratype (USNM 325101; Pl. 7, figs. 19–21) | 1.22 | 0.61 |
| Holotype (USNM 325098; Pl. 7, figs. 22–25) | 1.25 | 0.65 |
| Paratype (USNM 325102; Pl. 7, figs. 26–29) | 1.3 | 0.65 |

*Geographic distribution.*—See above, other localities.

*Geologic age.*—Early and Middle Pennsylvanian (Morrowan and Atokan).

Genus **BAIRDIACYPRIS** Bradfield, 1935

*Bairdiacypris* Bradfield, 1935, p. 93; Sohn, 1960, p. 57 (see for synonymy).
*Fabalicypris* Cooper, 1946, p. 59.

*Type-species.*—*Bairdiacypris deloi* Bradfield, 1935, p. 93, pl. 7, figs. 8, 9 ["Union Dairy Limestone Member" of the Hoxbar Formation (lowermost Missourian), Ardmore Basin, Oklahoma].

*Discussion.*—Coincidental with my earlier revision of this genus (Sohn, 1960, p. 57), I recognized *Fabalicypris* Cooper, 1946, and suggested that because species gradational between the two groups have been described, the two possibly should be considered as subgenera in *Bairdiacypris*. The internal morphology, marginal area, adductor-muscle-scar pattern, and hingement are still unknown. Because of variation in the ventroanterior offset of the larger valve (illustrated on Pl. 7, figs. 3, 4, 10, 11; Pl. 5, figs. 1, 2, 8, 9, on specimens from the same collection), the feature supposed to be diagnostic of *Fabalicypris* is inadequate to differentiate the two taxa. I therefore regard *Fabalicypris* as a junior subjective synonym of *Bairdiacypris*.

*Geologic range.*—Ordovician, Devonian through Permian, Lower Jurassic(?).

**Bairdiacypris** cf. **B. rectiformis**
(Shaver, 1959)
Plate 5, figures 1–9; Plate 7, figures 1–13

*Bairdia rectiformis* Shaver, 1959, p. 707, pl. 107, figs. 32, 33, text-fig. 2, figs. 9, 10 [Atokan equivalent, Butler County, Kentucky].
*Fabalicypris wetumkaensis* Cooper, 1946 (part), p. 61, pl. 6, figs. 12–15 (not figs. 16–19 = *Bairdiacypris warthini* (Bradfield, 1935)) [Seville Zone (Atokan), Henry County, Illinois]; Marple, 1952, p. 932, pl. 133, figs. 20, 21 ["Lower Mercer Limestone" (Atokan), Muskingum-Perry County line, Ohio].

*Diagnosis*.—Differs from the holotype of *Fabalicypris wetumkaensis* Cooper, 1946, in having a straight ventral margin and in having greatest convexity of posterior margin below midheight.

*Description*.—The left valve overlaps on all margins; the overreach is widest along the dorsum, having a steplike offset where the overlap meets the anterior margin. The ventral margin is straight, and the posterior margin is slightly convex; it trends down and backwards from about the posterior third of the greatest length to below the approximate midheight so that the greatest convexity is below midheight. The anterior margin curves gently upward at about the anterior quarter of the greatest length, and its greatest convexity is at or above the midheight.

*Measurements (in mm)*.—

| | greatest length | greatest height |
|---|---|---|
| Figured Specimen (USNM 325107; Pl. 5, figs. 6–9) | 0.95 | 0.42 |
| Figured Specimen (USNM 325109; Pl. 7, figs. 6, 7) | 1.10 | 0.55 |
| Figured Specimen (USNM 325106; Pl. 5, figs. 1–5) | 1.15 | 0.55 |
| Figured Specimen (USNM 325108; Pl. 7, figs. 1–5) | 1.20 | 0.55 |
| Figured Specimen (USNM 325111; Pl. 7, figs. 10–13) | 1.21 | 0.55 |
| Figured Specimen (USNM 325110; Pl. 7, figs. 8–9) | 1.22 | 0.58 |

*Discussion*.—Cooper (1946) illustrated two carapaces of *Fabalicypris wetumkaensis*; the holotype (1946, pl. 6, figs. 16–19) from the Brereton Zone (Des Moinesian) which Sohn (1960, p. 64) referred to *Fabalicypris warthini* (Bradfield, 1935) and a paratype (Cooper, 1946, pl. 6, figs. 12–15) from the Seville Zone. The two carapaces are not conspecific; they differ as indicated above in the synonymy of *Bairdiacypris* cf. *B. rectiformis*. Marple's (1952) *F. wetumkaensis* falls within the range of variation illustrated for *B.* cf. *B. rectiformis* (Pls. 5, 7). *Bairdia rectiformis* Shaver, 1959 (p. 787, pl. 107, figs. 32, 33, text-fig. 2, figs. 9, 10 = *Bairdiacypris*), from Atokan equivalent sediments in Butler County, Kentucky, resembles in lateral outline the specimens from West Virginia. Unfortunately, Shaver's types (InGS 238, InGS 240, and InGS 261) are poorly preserved in that parts of the shells have been dissolved. The poor preservation of the type-specimens of *Bairdiacypris rectiformis* (Shaver, 1959) prevents me from identifying with any degree of certainty the specimens from the Winifrede Limestone of Hennen (1914) as that species.

*Geographic distribution*.—

West Virginia: Fayette County, USGS colln. 12971-PC (USNM 325106–325111), 25726-PC (USNM 325112), 25727-PC (USNM 325113), Kanawha County, USGS collns. 25664-PC (USNM 325114), 25668-PC (USNM 325115).

Kentucky: Knott County, shale above Hindman coal bed (upper Atokan), USGS colln. 12920-PC (USNM 325116); Leslie County, USGS colln. 12923-PC (USNM 168214).

Illinois: Henry County.

Ohio: Muskingum-Perry County line.

*Geologic age*.—Middle Pennsylvanian (Atokan).

Suborder **CYTHEROCOPINA** Gründel, 1967

Superfamily **CYTHERACEA** Baird, 1850

Family **BYTHOCYTHERIDAE** Sars, 1926

Genus **MONOCERATINA** Roth, 1928

*Monoceratina* Roth, 1928, p. 16; Sylvester-Bradley and Kesling *in* Moore, 1961, p. Q268 [part].
*Triceratina* Upson, 1933, p. 29.

*Type-species*.—*M. ventrale* [*sic*] Roth, 1928, p. 16, text-figs. 1a–c [Wapanucka Limestone (Morrowan), Pontotoc County, Oklahoma].

*Discussion*.—The podocopid affinities are indicated by the presence of a calcified inner lamella (Pl. 6, figs. 15, 18, 19). Sylvester-Bradley and Kesling (*in* Moore, 1961, p. Q268) used both Paleozoic and post-Paleozoic species as a basis for their diagnosis of the genus; consequently, their diagnosis is too broad. Roth (1928) illustrated a carapace and stated (1928, p. 18) that the holotype is in the U.S. National Museum, number 71812. The slide with that number contains two left valves both approx. 0.6 mm in greatest length, that are obviously not the holotype. Records in the Museum dated Jan. 27, 1928, read "1 specimen, holotype," but Bassler and Kellett (1934, p. 413) did not list the holotype number under *M. ventrale* Roth. This is secondary evidence that the holotype was not in the Museum when Bassler and Kellett prepared their index. Roth (1928, p. 18) described also *Monoceratina ventrale* var. *magnum* from the middle portion of the Kansas City Formation, Kansas, holotype USNM No. 71813. This specimen is in the Museum collections,

and Bassler and Kellett (1934, p. 413) listed that number. According to Roth, this variety is present also in "samples . . . collected in . . . Tulsa County, Oklahoma."

To date, 44 species and nine in open nomenclature from Paleozoic rocks have been recorded in 72 publications. Coryell (1963) listed an additional 73 species in the Mesozoic. I do not have a record of the post-Mesozoic species and the additional Mesozoic species described since 1963. Three carapaces (USNM 85547) from the Wapanucka Limestone identified as *M. ventralis* by Harlton (1933, p. 21, pl. 7, figs. 3a, b) are approximately 0.8 mm in greatest length. These have an indistinct, shallow indentation in front of the ventral spine, a feature referred to by Roth (1928, p. 17) as ". . . a faint *Primitia*-like sulcus . . . ." Specimens of *Monoceratina* sp. in the Mississippian Helms Formation (Sohn, 1950a) have a well-defined albeit shallow indentation in front of and above the spine. *M. macoupeni* Scott and Borger, 1941, has a rounded node near the dorsal margin removed by approximately the width of its base from the anterior cardinal angle, as do the specimens illustrated in this paper (Pl. 6, figs. 16–23) as *M.* aff. *M. macoupeni*. The Late Permian *M. ampla* Khivintseva, 1969, also has a dorsoanterior node (tubercle). *M. compta* Khivintseva, 1969 (p. 104, pl. 12, figs. 3a–c), also from the Late Permian, was described as follows: "In the anterior cardinal angle and in the posterior third of the dorsal margin, the carapaces have cylindrical, mucronate spines." The specimen illustrated by a drawing as *Monoceratina* n. sp. by Bradfield (1935, p. 77, pl. 1, fig. 20) from the Deese(?) Formation (Des Moinesian) is shown as having ". . . two rounded tubercles situated one behind the other in the anterior cardinal area . . . ." Examination of that specimen (InUPC 1998) disclosed that the anteriormost tubercle consisted of adherent matrix that was easily removed, and an unpublished photograph of that specimen (approx. ×30) shows the shell continuing under the removed particle. Cooper (1946, p. 39) referred that specimen as well as those illustrated by Bradfield (1935, pl. 1, figs. 16–18) to *M. bradfieldi* Cooper, 1946, described from the Little Vermillion cyclothem (Virgilian) of northern Illinois. I do not, however, consider the specimens from Oklahoma to be conspecific with Cooper's species because *M. bradfieldi* differs in lateral outline and the location of the lateral spine from the specimens illustrated by Bradfield (1935, pl. 1, figs. 16–18), and the specimen Bradfield illustrated on plate 1, figure 20 has a distinct dorsoanterior node.

*Geologic range.*—Devonian through Permian, post-Paleozoic(?).

**Monoceratina winifredeana** new species
Plate 6, figures 1–15; Plate 11, figures 7–9

*Etymology of name.*—Named for the Winifrede Limestone of Hennen (1914).

*Holotype.*—USNM 325117.

*Paratypes.*—USNM 325118 through 325122.

*Type-locality.*—Harewood section, Fayette County, West Virginia, USGS colln. 12971-PC.

*Other localities.*—

West Virginia: Fayette County, USGS colln. 25726-PC (USNM 325123); Kanawha County, USGS collns. 25664-PC (USNM 325124), 25665-PC (USNM 325119), 25668-PC (USNM 325125), 12917-PC (USNM 325122).

Kentucky: Knott County, shale above Hindman coal bed (upper Atokan), USGS colln. 12920-PC (USNM 325126). Leslie County (Atokan), USGS colln. 21413-PC (USNM 325127), above Hindman coal bed, USGS colln. 12923-PC (USNM 168217).

*Type-level.*—Carbonaceous shale, from interval about 1.2 m (4 ft) to 5 m (16 ft) above the Chilton(?) coal bed.

*Diagnosis.*—Lateral pointing spine robust, does not extend ventrad past contact margin. Without nodes, ridges, sulci, or additional spines.

*Description.*—The lateral, dorsal, and ventral outlines are similar to those of *M. ventralis* Roth, 1928. The surface of the valve is evenly rounded in posterior outline, the greatest width is above the base of the spine (Pl. 6, fig. 5). The valve convexity merges smoothly downward to the contact margin and upward to the dorsal margin without any breaks as in *M.* sp. aff. *M. macoupeni* (Pl. 6, figs. 16, 20, 22).

The lateral surface has scattered pores, except for the surface of the spine and below the spine where the surface is wrinkled. The surface along the invaginated dorsum is smooth (Pl. 6, figs. 3, 10).

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Holotype (USNM 325117; Pl. 6, figs. 1–5) | 0.69 | 0.35 |
| Paratype (USNM 325118; Pl. 6, fig. 6) | 0.7 | 0.35 |
| Paratype (USNM 325119; Pl. 6, figs. 7, 8) | 0.7 | 0.32 |
| Paratype (USNM 325120; Pl. 6, fig. 9) | 0.8 | 0.4 |
| Paratype (USNM 325121; Pl. 6, figs. 10, 11) | 0.79 | 0.4 |
| Paratype (USNM 325122; Pl. 6, figs. 12–15) | 0.85 | 0.43 |
| Figured Specimen (USNM 325127; Pl. 11, figs. 7–9) | 0.80 | 0.41 |

*Discussion.*—The spine is thicker at the base and apparently blunter than on *M. ventralis*. The latter species has in front of the spine an anterior-trending keel-like ridge subparallel to the contact margin, but not as robust as the ridge on *M. ardmorensis* (Harlton, 1927) illustrated herein (Pl. 11, figs. 11, 12). This ridge

is not present in the new species (compare Pl. 6, figs, 1, 4, 6, 8, 11, 13 with Roth's (1928) text-figs. 1a, 2a, reillustrated in Moore (1961, text-fig. 195, figs. 3a, b)). The holotype (Pl. 6, figs. 1–5) and a paratype (Pl. 6, fig. 8) have minute spinelets along the ventral third of the anterior margin, but most of the specimens do not have these spinelets preserved.

*Geographic distribution.*—See above, other localities.

*Geologic age.*—Middle Pennsylvanian (Atokan).

**Monoceratina** sp. aff. **M. macoupeni** Scott and Borger, 1941
Plate 6, figures 16–23; Plate 11, figure 10

*Monoceratina macoupeni* Scott and Borger, 1941, p. 355, pl. 49, figs. 2, 3 ["Macoupin Formation" (Missourian), Lawrence County, Illinois].

*Monoceratina lawrencevillensis* Scott and Borger, 1941, p. 355, pl. 49, fig. 8 [same collection as above].

?*Monoceratina macoupeni* Scott and Borger. Cooper, 1946, p. 39, pl. 1, fig. 13 [Gimlet Zone, Marmaton Group (Des Moinesian), Marshall County, Illinois]; Marple, 1952, p. 927, pl. 133, fig. 3 ["Poverty Run Limestone Member" and "Lower Mercer Limestone Member," Kanawha Formation, Muskingum County, Ohio].

*Discussion.*—The specimens on hand are similar to Scott and Borger's (1941) *M. macoupeni* in having a node on the anterior third of the valve near the dorsal margin and a backward pointing spine. They differ in that the spine is more robust in having a subdued ventral lobe extending forward from the spine, and probably in the absence of spinelets along the anterior margin. Both Cooper (1946, p. 39) and Marple (1952, p. 927) correctly considered *M. lawrencevillensis* a junior subjective synonym of *M. macoupeni*. The absence of anterior spinelets on the two illustrated valves of *M. lawrencevillensis* is probably due to preservation, as both of the above-mentioned species are from the same poorly silicified assemblage. Cooper (1946) illustrated a unique cast that does not have a dorsoanterior node. Marple (1952) illustrated a left valve with a missing posterior that has a well-defined dorsoanterior node and a ". . . row of smaller, diminishing nodes along the dorsal margin . . ." (Marple, 1952, p. 927). The additional nodes may be adhering particles because they are not rounded.

Although several specimens are available, they are from borehole cores; consequently, they are not formally named. The four illustrated valves show the dorsoanterior node, calcified inner lamella, and the hinge of the right valve. They differ from *M. winifredeana* in having a dorsoanterior node and a lobe extending forward from the spine. Three carapaces from the Bostwick Member of the Lake Murray Formation (Atokan), Carter County, Oklahoma (USGS colln. 12969-PC, USNM 325131) belong to *M. macoupeni*. These carapaces differ from the specimens on hand in having the lateral spine closer to midlength. Consequently, I am confident regarding the difference between the two taxa.

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Figured Specimen (USNM 325128; Pl. 6, figs. 16, 17) | 0.78 | 0.33 |
| Figured Specimen (USNM 325129; Pl. 6, figs. 18–21) | 0.7+ | 0.37 |
| Figured Specimen (USNM 325130; Pl. 6, figs. 22, 23) | 0.8+ | 0.4 |
| Figured Specimen (USNM 168219; Pl. 11, fig. 10) | 0.65 | 0.41 |

*Geographic distribution.*—

West Virginia (borehole cores): Fayette County, USGS colln. 25726-PC (USNM 325128); Kanawha County, USGS collns. 12917-PC (USNM 325129, 325130), ?25664-PC (USNM 325132).

Illinois: Lawrence County, Marshall County.

Kentucky: Leslie County, USGS colln. 21413-PC (USNM 168219).

Ohio: Muskingum County.

*Geologic age.*—Middle and lower Upper Pennsylvanian (Atokan to Missourian).

Suborder **METACOPINA** Sylvester-Bradley, 1961

Pending the revision of the American Treatise (Moore, 1961), I follow the classification of this group by Sylvester-Bradley (*in* Moore, 1961, p. Q358).

Superfamily **HEALDIACEA** Harlton, 1933

Revision of this group is beyond the scope of this study. See Sohn (1965) for a discussion of this superfamily.

Family **HEALDIIDAE** Harlton, 1933

Genus **HEALDIA** Roundy, 1926

*Geologic range.*—Devonian through Permian, lower Mesozoic(?).

**Healdia ehlersi** Bradfield, 1935
Plate 2, figures 14–33; Plate 11, figure 1

*Healdia ehlersi* Bradfield, 1935, p. 107, pl. 9, figs. 11a, b [Deese(?) Formation (Des Moinesian), Ardmore Basin, Oklahoma]; Cooper, 1946, p. 82, pl. 12, figs. 6–8 [shale on top of "Macoupin Limestone" (Missourian), Edgar County, Illinois].

*Healdia angulata* Bradfield, 1935, p. 110, pl. 9, figs. 12, 13 [Deese(?) Formation (Des Moinesian), Ardmore Basin, Oklahoma].

*Healdia nucleolata* Knight *sensu* Cooper, 1946, p. 84, pl. 12, figs. 42–45 [Ferdinand to Summum zones (Atokan to Des Moinesian), Spencer County, Indiana; Adams and Brown Counties, Illinois].

not *Healdia nucleolata* Knight, 1928, p. 329, pl. 44, figs. 4a–c [paratypes examined].
?*Healdia* sp. Marple, 1952, p. 934, pl. 134, fig. 14 ["Lower Mercer Limestone Member" of Pottsville Formation, Muskingum-Perry County line, Ohio].

*Discussion*.—The anterior marginal rims (carinae) distinguish this species. Although Bradfield (1935) recorded an anterior marginal rim only on the left valve, Cooper (1946, p. 84) noted ". . . a narrow flat margin . . ." on both valves as illustrated herein (Pl. 2). The other species of *Healdia* that have anterior marginal structures differ from *H. ehlersi* as follows:

*Healdia cara* Bradfield, 1935. Late Des Moinesian, Carter County, Oklahoma. Structure on right valve only, no posterior ridges or spines.
*H. nasuta* Drexler, 1958. Early Jurassic, southwestern Germany. Structure on right valve only, one ventroposterior spine without posterior ridges, and prionodont hinge. This species is probably not a *Healdia*.
*H. ratra* Gründel, 1961. *Gattendorfia* Stage (Early Mississippian), Thuringia, East Germany. Spine on right valve only, different lateral outline.
*H. subcarinata* Morey, 1935. Early Mississippian, Callaway County, Missouri. Structures on anterior and posterior margins.
*H. sulcata* Cooper, 1947. Late Mississippian, Johnson County, Illinois. Posterior ridge bordered on anterior side by semicircular furrow.

The posterior ridges and spines appear to vary among individuals and on opposing valves of the same carapace, and are similar only in that respect to *H. oklahomaensis* Harlton, 1927, that has spines on the right valve and a ridge on the left valve. The specimens illustrated on Plate 2, figures 14–17, 24–28, and 31–33 are from the same collection. The ridge on the left valve (Pl. 2, figs. 14, 26, 33) trends toward the anterior, and on the right valve (Pl. 2, figs. 16, 28, 32), this ridge is perpendicular. The carapace from a different collection (Pl. 2, figs. 29, 30) has an upper spine on the left valve. Bradfield's holotype of *H. ehlersi* has two well-developed spines on the right valve, but the holotype of *H. angulata* from the same collection, considered by Cooper (1946, p. 82) as a synonym, has a posterior ridge on the right valve, does not have spines, and has a ridge curving toward the dorsoanterior. The spines may be on the ridge or slightly behind the ridge. Although Bradfield (1935, p. 110) reported an anterior marginal rim only on the left valve, Cooper (1946, p. 82) noted ". . . narrow flat margin . . . on both valves . . ." as illustrated herein (Pl. 2, figs. 24, 25). This feature appears to be constant in this species and may be restricted to forms of from Atokan through Missourian age, even if my conception of the species proves to be too broad and more than one species is included in my synonymy.

The specimens on hand are slightly smaller than Bradfield's, which is 0.64 mm in greatest length. Cooper recorded the greatest length for the specimen from Illinois as 0.78 mm. Bradfield (1935, p. 110) recorded the greatest length of *H. angulata* to be 0.83 mm, and Cooper (1946, p. 85) stated that the Illinois specimen of *H. nucleolata* is 0.67 mm in greatest length. Marple's specimen is only 0.41 mm in greatest length.

*Measurements (in mm)*.—

| | greatest length | greatest height |
|---|---|---|
| Figured Specimen (USNM 325133; Pl. 2, figs. 14–17) | 0.52 | 0.40 |
| Figured Specimen (USNM 325134; Pl. 2, figs. 18–20) | 0.52 | 0.35 |
| Figured Specimen (USNM 325135; Pl. 2, figs. 21–23) | 0.53 | 0.35 |
| Figured Specimen (USNM 325136; Pl. 2, figs. 24–28) | 0.52 | 0.35 |
| Figured Specimen (USNM 325137; Pl. 2, figs. 29, 30) | 0.51 | 0.31 |
| Figured Specimen (USNM 325138; Pl. 2, figs. 31–33) | 0.52 | 0.39 |

Specimens from other collections listed below range in greatest length from 0.49 mm to 0.58 mm.

*Geographic distribution* (in addition to the previously recorded localities: see synonymy).—

West Virginia: Fayette County, USGS collns. 12971-PC (USNM 325133, 325136, 325138), 25726-PC (USNM 325139); Kanawha County, USGS collns. 25661-PC (USNM 325140), 25664-PC (USNM 325141), 25665-PC (USNM 325142), ?25668-PC (USNM 325143), 25669-PC (USNM 325137), 26774-PC (USNM 325134, 325135).

Kentucky: Leslie County, shale just above Hindman coal bed (upper Atokan), USGS colln. 12923-PC (USNM 325144); Butler County, shale in Tradewater Formation (upper Atokan), USGS colln. 12948-PC (USNM 168223).

*Geologic age*.—Middle and Late Pennsylvanian (Atokan to Missourian).

### Genus **PSEUDOBYTHOCYPRIS** Shaver, 1958

*Bythocypris* Knight, 1928, p. 326 [not Brady, 1880].
*Pseudobythocypris* Shaver, 1958, p. 122.
*Coryellites* Kellett. Cooper, 1946, p. 55.
not *Coryellites* Kellett, 1936, p. 775 (new name for *Coryellina* Kellett, 1935, not Bradfield, 1935).

*Type-species*.—*Bythocypris pediformis* Knight, 1928, p. 326, pl. 44, figs. 3a–c [upper part of Fort Scott Limestone (Des Moinesian), Missouri].

*Discussion*.—Shaver (1958) adequately described this genus. He noted that Cooper (1946) assigned many

of the Paleozoic species previously referred to or described in the extant genus *Bythocypris* Brady, 1880, to *Coryellites* Kellett, 1936 [new name for *Coryellina* Kellett, 1935]. The holotype of the type-species, *Coryellites firma* (Kellett, 1935) is a carapace (USNM 90101) that has, on the left valve, a subdued posteroventral ridge with a depression in front of that ridge, a feature not present on the left valves of the two species illustrated herein (Pl. 8, figs. 3, 4, 9, 16, 17). All the species referred to *Coryellites* by Cooper (1946) that do not have the diagnostic ridge on the left valve belong in *Pseudobythocypris*.

Shaver illustrated the adductor-muscle-scar pattern of *P. pediformis* by drawings. The scar patterns illustrated herein on Plate 8, figures 21, 23 are the same as those by Shaver (1958, text-fig. 1, figs. 5, 6) and confirm the assignment of this genus to the Healdiacea.

*Geologic range*.—Mississippian through Permian.

**Pseudobythocypris pediformis** (Knight, 1928)
Plate 8, figures 14–24

*Bythocypris pediformis* Knight, 1928, p. 326, pl. 44, figs. 3a–c [upper part of Fort Scott Limestone (Des Moinesian), Missouri]; Cordell, 1952, p. 100, pl. 20, figs. 27–32, 36–44 [Pleasanton Formation to Oread Limestone. (Missourian-Virgilian)].

*Coryellites pediformis* (Knight). Cooper, 1946, p. 58, pl. 5, figs. 19–21 [Seville to Shumway zones (Atokan through Virgilian), Illinois].

*Pseudobythocypris pediformis* (Knight). Shaver, 1958, p. 122–136, text-fig. 1 [Knight's material].

not *Pseudobythocypris pediformis* (Knight, 1928). Sanchez de Posada, 1977, p. 423, pl. 5, figs. 5–9.

*Discussion*.—The National Museum of Natural History (USNM) and USGS collections contain topotype specimens of this species. The shape of the posterior margin varies greatly, particularly in the development of the ventroposterior point (Pl. 8, figs. 15, 16, 18, 22, 24). Cordell (1952) referred to 11 described species as junior subjective synonyms of *P. pediformis*, and Sanchez de Posada (1977, p. 423) accepted Cordell's synonymy. I do not consider *Bythocypris pediformis*, identified by Kellett (1935) from the Permian Fort Riley Limestone of Kansas (USNM 90099), to be conspecific. The species illustrated by Sanchez de Posada differs in posterior margin and dorsal outline. Evaluation of the complete synonymy by Cordell is beyond the scope of this paper.

The specimens illustrated (Pl. 8, figs. 14–24) are all within the limits of variation of Knight's material.

*Measurements (in mm)*.—

| | greatest length | greatest height |
|---|---|---|
| Figured Specimen (USNM 325145; Pl. 8, figs. 14–17) | 0.72 | 0.45 |
| Figured Specimen (USNM 325146; Pl. 8, figs. 18–20) | 0.66 | 0.41 |
| Figured Specimen (USNM 325147; Pl. 8, figs. 21, 22, left valve) | 0.63 | 0.42 |
| Figured Specimen (USNM 325148; Pl, 8, figs. 23, 24, right valve) | 0.65 | 0.40 |

*Geographic distribution* (see synonymy).—

West Virginia: the type-locality of the Winifrede Limestone of Hennen (1914), USGS colln. 26774-PC (USNM 325145, 325146), and the Harewood section, USGS colln. 12971-PC (USNM 325147, 325148).

Kentucky: Leslie County, "Magoffin beds," USGS colln. 21413-PC (USNM 168209).

*Geologic age*.—Middle and Late Pennsylvanian (Atokan, Des Moinesian, Missourian, Virgilian).

**Pseudobythocypris? enigmatica** new species
Plate 8, figures 1–13

*Etymology of name*.—So named because of the questionable generic designation.

*Holotype*.—USNM 325149.

*Paratypes*.—USNM 325150 through 325152.

*Type-locality*.—Harewood section, Fayette County, West Virginia, USGS colln. 12971-PC.

*Other localities*.—

West Virginia: type-locality of the Winifrede Limestone of Hennen (1914), Kanawha County, USGS colln. 26774-PC (USNM 325150, 325151), 25664-PC (USNM 325153), 25665-PC (USNM 325154), 25668-PC (USNM 325155).

*Diagnosis*.—Dorsal margin convex, greatest height at or slightly behind midlength, end margins rounded, posterior higher than anterior, ventral margin straight. Dorsal outline subovate, heteromorphs with gently curved sides, anterior blunt and posterior wider, in tecnomorphs anterior more pointed, greatest width at or slightly behind midlength. Posterior outline with gently curved sides. Adductor-muscle-attachment scars circular, with large discrete individual spots.

*Description*.—The carapace is small, to 0.55 mm in greatest length, subovate. The left valve overlaps the right on all margins. The dorsal outline of heteromorphs (presumed females) are subelliptical with gently curved sides and blunt ends of which the posterior end is wider than the anterior. The greatest width is approximately at midlength. The dorsal outline of tecnomorphs (preadults and presumed males) is pointed towards the anterior.

The posterior outline is subelliptical with gently convex ends; the greatest width is at approximate midheight.

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Holotype (USNM 325149; Pl. 8, figs. 1–4) | 0.55 | 0.32 |
| Paratype (USNM 325150; Pl. 8, figs. 5, 6) | 0.50 | 0.34 |
| Paratype (USNM 325151; Pl. 8, figs. 7–9) | 0.45 | 0.30 |
| Paratype (USNM 325152; Pl. 8, figs. 10–13) | 0.51 | 0.31 |

*Discussion.*—The hinge of a subadult left valve (Pl. 8, figs. 10–13) extends from the posterior cardinal angle to the highest point, which is the junction with the dorsoanterior slope; it appears to consist of a groove with vertical dentition (Pl. 8, figs. 10, 12). I am not certain whether the vertical dentition is an artifact due to preservation. This is the reason for the questionable assignment of the species to *Pseudobythocypris,* which is described as having a cardine hinge (Cooper, 1946, p. 55).

Gramm (1982, pl. 2; pl. 3, figs. 1–12) illustrated for the first time the adductor-muscle-attachment scar pattern and the hinge of *Healdianella darwinuloides* Posner, 1951, the type-species of *Healdianella* Posner, 1951, that are similar to my illustrations (Pl. 8, figs. 10, 11). Future study may transfer *P.*? *enigmatica* n. sp. to *Healdianella*.

*Geographic distribution.*—See above, other localities.

*Geologic age.*—Middle Pennsylvanian (Atokan).

Order **PLATYCOPIDA** Sars, 1866

*Discussion.*—Living *Cytherella* Jones, 1849 are incapable of swimming. Except for the adductor-muscle-attachment scar, the shell morphology of the Cavellinacea is identical to that of the Cytherellacea; consequently, it is reasonable to assume that the Platycopida could not swim.

Suborder **PLATYCOPINA** Sars, 1866

Superfamily **CAVELLINACEA** Egorov, 1950

See Sohn (1968, p. 17) for discussion of this taxon.

Family **CAVELLINIDAE** Egorov, 1950

Genus **CAVELLINELLA** Bradfield, 1935

*Cavellinella* Bradfield, 1935, p. 136.
not *Cavellina* (*Cavellinella*) Polenova and Zaspelova *in* Polenova, 1953, p. 56; Rozhdestvenskaja, 1959, p. 142 [junior objective homonym. Dr. Polenova was informed (by letter in May 1981)].

*Type-species* (monotypic).—*Cavellinella casei* Bradfield, 1935, p. 136, pl. 12, figs. 11a, b [Early Pennsylvanian (Morrowan), Carter County, Oklahoma].

*Diagnosis.*—Bradfield (1935, p. 136) described *Cavellinella* as follows:

Carapace oval to suboval in lateral view; greatest thickness near the posterior end; dorsal border arched; anterior margin broadly rounded; posterior margin more sharply rounded; ventral margin convex; valves unequal, the right the larger, overlapping the left all around, but most on the dorsal and ventral margins; a pronounced lunate ridge encircles the posterior end of each valve about one-fifth the length from the posterior end; surface smooth.

Based on this study the diagnosis should be expanded to include the fact that species in this genus are dimorphic in width of posterior (Pl. 9, figs. 1, 3, and 14, 16) and that the female has an internal septum in the posterior quarter of the valve (Pl. 9, figs. 20, 22).

*Discussion.*—Bradfield's original specimens are from two collections. He illustrated a carapace of *C. casei,* the type-species, in right and dorsal views, for which he recorded the following measurements: length 0.59 mm, height 0.37 mm, and thickness 0.24 mm. Cooper (1946, p. 72) questionably placed *C. casei* Bradfield, 1935 in synonymy with *Cavellina fittsi* Kellett, 1935, and explained,

*Cavellinella casei* Bradfield is a very small specimen with a curved ridge bordering the posterior margin similar to the young of many species of *Cavellina,* particularly *C. fittsi,* so Bradfield species have been tentatively placed in synonymy with this species.

This may be the reason for the assignment of *Cavellinella*(?) as a questionable synonym of *Cavellina* Coryell, 1928, by Shaver (*in* Moore, 1961, p. Q369). The Russian Treatise (Chernysheva, 1960, p. 333) recognized Bradfield's genus as valid.

Kellett (1935, p. 147, pl. 18, figs. 2a–e, 2f–3g) illustrated early molts of *C. fittsi* Kellett, 1935 (figs. 3a–g) from the same locality as the type lot of that species from the Upper Pennsylvanian Howard Limestone of Kansas. I have examined two slides (USNM 90115) that she deposited in the National Museum of Natural History. One contains the holotype (1.10 mm in greatest length) and the other contains three female carapaces about 1.1 mm in greatest length. Neither slide contains any of the "early molts" illustrated by Kellett on plate 18 as figures 3a–g. These "paramolts" do have a posterior curved ridge; they seem from the illustrations to range in greatest length from 0.36 mm to 0.55 mm. The fact that my large specimens (greatest length 0.74 mm to 1.44 mm) from the Winifrede Limestone of Hennen (1914) have a posterior ridge indicates that Kellett's "early molts" should not be referred to *Cavellina*. Crespin (1945, p. 33) described as *Cavellina springsurensis,* from the Permian of Australia, a specimen 1.21 mm long that has a curved posterior ridge on each valve. She compared this form with *Ca-*

*vellina fittsi* Kellett, 1935. This species, however, has a larger left valve, and probably belongs to one of the genera discussed below.

Ostracodes having lateral curved ridges are common in the Paleozoic. The original description of *Birdsallella* Coryell and Booth, 1933, fits the diagnosis of *Cavellinella,* although the orientation was reversed 180°. However, the type-species from the Wayland Shale (Member of the Graham Formation) in Young County, Texas, *B. simplex* Coryell and Booth, 1933, was described as ". . . valves constricted vertically just anterior [posterior] to the center . . ." (1933, p. 271), a feature that discriminated between the two genera. It may be significant that the 17 species plus three in open nomenclature subsequently described in or referred to *Birdsallella* are Silurian or Devonian in age, that several of those species have lateral curved ridges also near the anterior of the valves, and that the platycopid dimorphism illustrated herein for *Cavellinella* has not been recorded in any of the species of *Birdsallella*.

As illustrated on Plate 9, figures 15, 20, 22, the new species tentatively referred to *Cavellinella* exhibits sexual dimorphism by having an internal septum in the posterior area of females, a feature typical in the Platycopida. This feature has not been recorded in the Healdiacea Harlton, 1933, in which some genera have posterior ridges but the carapaces are usually much smaller. A very young growth stage of *Cavellinella*? *pricei* n. sp. is shown with *Healdia* (Pl. 2, figs. 11–13) in order to illustrate the difference between the two genera.

*Aurigerites* Roundy, 1926, and *Punctomosea* Stover, 1956 have curved ridges near the posterior, but the left valve is larger in both genera, and *Punctomosea* has a pitted area in front of the ridge. *Bythocyproidea* Stewart and Hendrix, 1945, has a posterior ridge only on the smaller right valve.

*Geologic range*.—Mississippian(?) and Pennsylvanian.

**Cavellinella**? **pricei** new species
Plate 2, figures 11–13; Plate 5, figures 21–23;
Plate 9, figures 1–23

*Cavellinella casei* Bradfield. Marple, 1952, p. 932, pl. 134, figs. 4–6 ["Lower Mercer Limestone Member" of the Pottsville Formation, Vinton County, Ohio].

*Cavellinella casei* Bradfield. Thompson and Shaver, 1964, p. 19, bottom fig. under Section 58 [Atokan, Spencer County, Indiana].

not *Cavellinella casei* Bradfield, 1935, p. 136, pl. 12, figs. 11a, b.

*Healdia fabalis* Cooper. Marple, 1952, p. 933, pl. 134, figs. 8, 9 [Lower Mercer Limestone Member of Pottsville Series, Muskingum County, Ohio].

not *Healdia fabalis* Cooper, 1946, p. 82, pl. 12, figs. 3–5.

*Etymology of name*.—Named in honor of Dr. W. Armstrong Price, Paleontologist, West Virginia Geological Survey, who pioneered the study of Pennsylvanian invertebrates in that state.

*Holotype*.—USNM 325156.

*Paratypes*.—USNM 325157 through 325164.

*Type-locality*.—Harewood section, Fayette County, West Virginia, USGS colln. 12971-PC.

*Other localities*.—

West Virginia: Kanawha County, USGS collns. 25656-PC (USNM 168203), 25664-PC (USNM 168204), 25665-PC (USNM 168205) and 25668-PC (USNM 168206).

Kentucky: Pike County, top of "Kendrick shale" (Morrowan) USGS colln. 21604-PC (USNM 325165).

*Diagnosis*.—Differing from *C. casei* Bradfield, 1935, in posterior ridges on both valves being closer to posterior margin, having shorter radius of curvature, and not extending to dorsal and ventral margins; right valve not overlapping anterior margin.

*Discussion*.—Marple (1952, pl. 134, figs. 4–6) illustrated a carapace and a right valve as *C. casei*; their greatest lengths were 0.56 mm and 0.61 mm, and their greatest heights were 0.35 mm and 0.41 mm. These specimens fall between the growth stages illustrated herein on Plate 9, figures 7 and 8. The carapace she illustrated as *Healdia fabalis* Cooper, 1946, belongs to *C. pricei* and is not a healdiid. *H. fabalis* Cooper, 1946, has the left valve overlapping the right as in *Healdia ehlersi* Bradfield, 1935 (compare Pl. 2, fig. 11 with Pl. 2, figs. 16, 19, 22) and as originally illustrated bears two posterior spines and not ridges as in *Cavellinella*.

Text-figure 3 is a length/height graph based on measurement of specimens from the type-locality. I measured the length, height, and width with an ocular micrometer that has 0.1-mm divisions and estimated to the nearest 0.01 mm. The specimens were oriented with the smaller valves up, and the length and height were measured on the larger right valve. The width measurements were not plotted because of the errors introduced in positioning the specimens on their ventral margins.

Thompson and Shaver (1964, p. 6) illustrated the left view of a carapace as *Cavellinella casei* Bradfield that closely resembles the instar from the Winifrede Limestone of Hennen (1914) illustrated herein on Plate 9, figure 7. Their specimen is from the Fulda Limestone bed of the Lead Creek Limestone Member of the Mansfield Formation, considered by Shaver and Smith (1974, p. 15) to be Atokan equivalent. Knox (1975, p. 81, pl. 12, figs. 9–16) illustrated as *Cavellinella casei* Bradfield from the middle part of the Morrow Group

(Lower Pennsylvanian), Cherokee County, Oklahoma, a specimen that probably belongs to *C. pricei*.

The smaller valve of *C. pricei* has a thin ridge concentric with the free margins and a smooth shelf or flange that fits into the overlapping valve (Pl. 9, figs. 3, 4, 17). The larger valve does not overreach along the anterior margin as in *C. casei*. There are no pits inside the curved ridge as in the Late Mississippian *C. moreyi* Coryell and Rosanski, 1942.

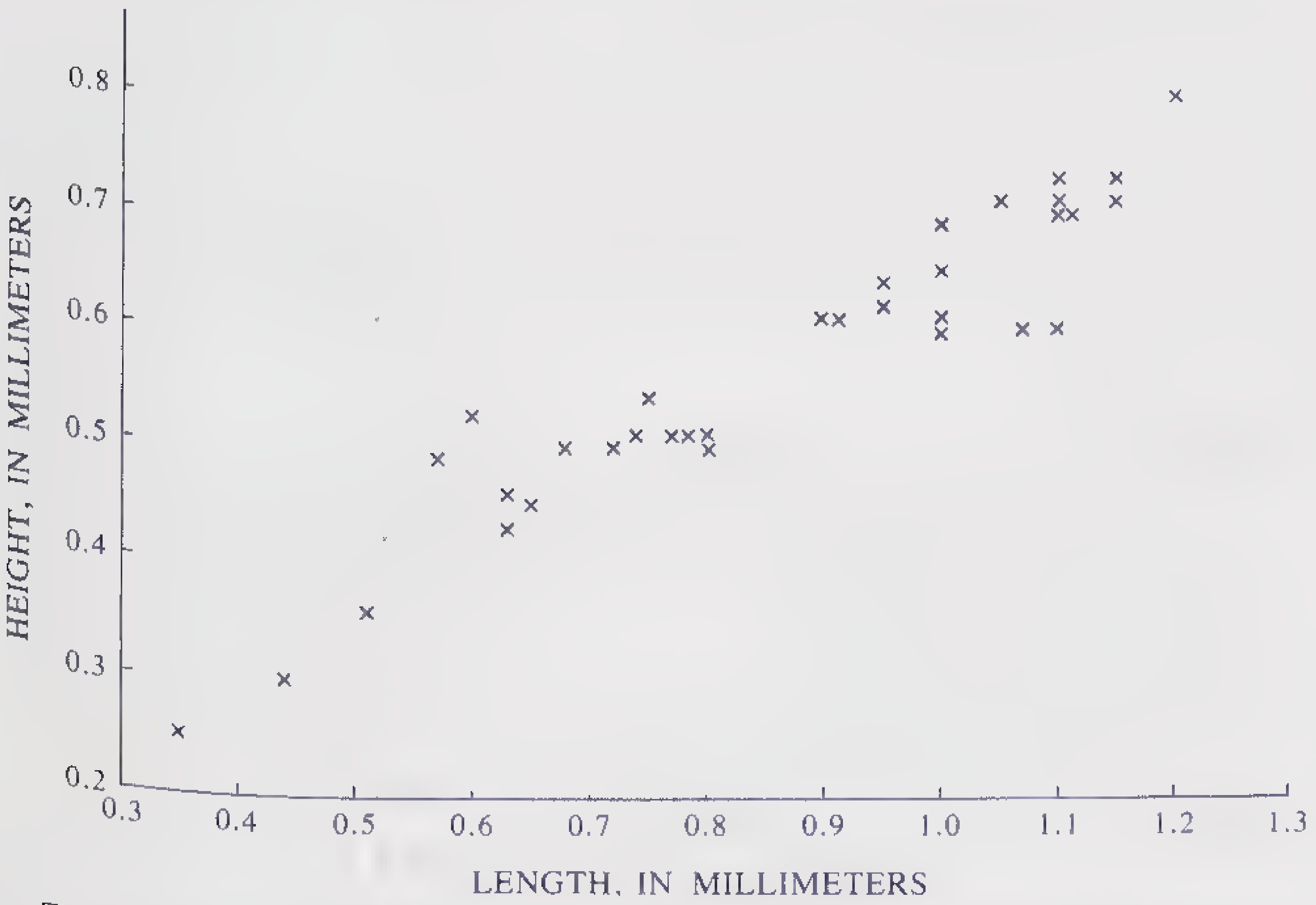
The presence of an inner partition near the posterior of the valve similar to that known in the Platycopida (Pl. 9, figs. 20, 22) and absence of this partition on a valve of the same size (Pl. 9, fig. 15) proves that the species is dimorphic. Smaller specimens (Pl. 2, figs. 11–13) have a less curved, almost straight posterior ridge that extends higher above the valve surface relative to the size of the valve than on later growth stages. Because these small specimens are associated with larger individuals, they are assumed to be conspecific.

*Measurements (in mm).*—

| | greatest length | greatest height |
|---|---|---|
| Paratype (USNM 325163; Pl. 2, figs. 11–13) | 0.44 | 0.30 |
| Paratype (USNM 325158; Pl. 9, fig. 7) | 0.51 | 0.36 |
| Paratype (USNM 325159; Pl. 9, figs. 8, 9) | 0.74 | 0.51 |
| Paratype (USNM 325160; Pl. 9, figs. 10–13) | 0.91 | 0.61 |
| Paratype (USNM 325162; Pl. 9, figs. 19–23) | 1.07 | 0.60 |
| Paratype (USNM 325161; Pl. 9, figs. 14–18) | 1.10 | 0.60 |
| Paratype (USNM 325157; Pl. 9, figs. 5, 6) | 1.10 | 0.70 |
| Holotype (USNM 325156; Pl. 9, figs. 1–4) | 1.10 | 0.71 |
| Paratype (USNM 325164; Pl. 5, figs. 21–23) | 1.11 | 0.70 |
| Unfigured Specimen (USNM 325165) | 1.44 | 0.70 |

*Geographic distribution.*—See above, in synonymy and under *Other localities*.

*Geologic age.*—Early and Middle Pennsylvanian (Morrowan and Atokan).




Text-figure 3.—Length–height ratios of *Cavellinella? pricei* in its type-locality.

## APPENDIX

### Collection Localities

Collections examined in this study are from the localities described below. These localities are designated using U.S. Geological Survey topographic quadrangle maps, and some are also shown on Text-figure 1. All locality numbers are part of the U.S. Geological Survey Upper Paleozoic card catalogue. Field numbers are given in parentheses after the locality numbers, as applicable.

#### West Virginia

12971-PC (5/13/1/79).—Carbonaceous shale in Winifrede Limestone of Hennen (1914), from interval about 1.2 m (4 ft) to 5 m (16 ft) above the Chilton(?) coal bed. Harewood section, Stop 18B of Englund *et al.* (1979, p. 91). Montgomery 7½ minute quadrangle, Fayette County. Collected by I. G. Sohn. See Text-figure 1, locality 10, for geographic location.

26774-PC (80-G-5).—Winifrede Limestone of Hennen (1914) (type-locality). From northern bank of stream in North Hollow of Fields Creek on northern side of company road at point 0.24 km (0.15 mi) east of BM 945, near Carbon Fuels Co.'s tipple at mouth of South Hollow. Belle 7½ minute quadrangle, Kanawha County. Collected by M. Gordon, Jr., T. W. Henry, R. C. Douglass, and E. L. Yochelson, Oct. 10, 1976, and June 31, 1980. See Text-figure 1, locality 9, for geographic location. (= 26713-PC.)

25644-PC.—Thin fossiliferous shale in Winifrede Limestone of Hennen (1914), borehole No. 1, core from interval 0.19 cm (7.5 in) to 0.24 cm (9.5 in) above base of thin coal occurring at altitude 258.7 m (848.8 ft) at point 69.2 m (227 ft, 1 in) below top of "Kanawha black flint" of White (1891). Borehole located on left side of road on Putney Ridge at forks of road to Mt. Desert Lookout Tower [Left Fork of Kelly's Creek], near Mammoth, W. Va. Mammoth 7½ minute quadrangle, 38°17′27″ N. lat., 81°22′27″ W. long., Kanawha County. Collected by T. W. Henry, 1974. See Text-figure 1, locality 4, for geographic location. (= USGS collns. 25643-PC, 25645-PC, 25648-PC, and 12906-PC [from same borehole]).

12917-PC.—Thin fossiliferous shale in Winifrede Limestone of Hennen (1914), borehole No. 2 from core from interval 0.30 m (1 ft) to 0.38 m (15 in) above base of thin coal that occurs at altitude 257.6 m (885 ft, 1 in) at point 65.86 m (216 ft, 1 in) below top of "Kanawha black flint" of White (1891). Borehole located on ridge between Bear Hollow and Deadening Hollow. 38°17′28″ N. lat., 81°19′38″ W. long. Mammoth 7½ minute quadrangle, Kanawha County. Collected by T. W. Henry, 1974. See Text-figure 1, locality 5, for geographic location. (= USGS collns. 12914-PC through 12916-PC, 12918-PC, and 25664-PC through 25672-PC [from same borehole]).

25690-PC.—Thin fossiliferous shale in Winifrede Limestone of Hennen (1914), borehole No. 3, from core from interval 0.483 m (19 in) to 0.559 m (22 in) above base of thin coal that occurs at altitude 258.59 m (848.4 ft) at a point 67.33 m (220 ft, 11 in) below top of "Kanawha black flint" of White (1891). Happy Hollow of Campbells Creek near Putney, Quick 7½ minute quadrangle, 38°18′12″ N. lat., 81°22′43″ W. long., Kanawha County. Collected by T. W. Henry, 1974. See Text-figure 1, locality 3, for geographic location. (= USGS collns. 25682-PC, 25683-PC, 25684-PC, 25685-PC, 25687-PC, 25688-PC, 25689-PC, 25691-PC [from same borehole]).

25656-PC.—Thin fossiliferous shale in Winifrede Limestone of Hennen (1914), borehole No. 4, from core from interval 3.4 m (11.15 ft) to 3.47 m (11.4 ft) below base of thin coal bed that occurs at altitude 282.2 m (926.0 ft) at point 56.13 m (184 ft, 5 in) below top of "Kanawha black flint" of White (1891). Borehole located on ridge between Eightmile Fork of Campbells Creek, Quick 7½ minute quadrangle, 38°18′48″ N. lat., 81°24′50″ W. long., Kanawha County. Collected by T. W. Henry, 1974. See Text-figure 1, locality 1, for geographic location. (= USGS collns. 12910-PC through 12913-PC and 25658-PC through 25663-PC [from same borehole]).

12908-PC.—Thin fossiliferous shale in Winifrede Limestone of Hennen (1914), borehole No. 5, from core from interval 3.63 m (11.9 ft) to 3.72 m (12.2 ft) below base of thin coal bed that occurs at altitude 265.9 m (872.4 ft) at point 53.52 m (175 ft, 7 in) below top of "Kanawha black flint" of White (1891). Borehole located on top of ridge, 15.24 m (50 ft) northwest of two 50.8-cm (20-in) gas lines and located between Eightmile Fork of Campbells Creek and Stone Hollow of Campbells Creek, Quick 7½ minute quadrangle, 38°19′01″ N. lat., 81°23′42″ W. long., Kanawha County. Collected by T. W. Henry, 1974. See Text-figure 1, locality 2, for geographic location. (= USGS collns. 12907-PC, 12909-PC, and 25677-PC through 25682-PC [from same borehole]).

25725-PC.—Winifrede Limestone of Hennen (1914), borehole No. 6 (USGS core No. IC-76-1), core sample of medium- to dark-gray calcareous shale from 63.4 m (208 ft) to 64.3 m (211 ft) below surface (and base of Coalburg coal bed), Gauley Mountain (map elevation 1,630 ft), about 1,371.6 m (4,500 ft) southwest of Beech Glen and 1,676.4 m (5,500 ft) northeast of Alta, on divide between Schoolhouse Branch and Buck Run, NE¼ Gauley Bridge 7½ minute quadrangle, Fayette County. Collected by H. H. Arndt, Apr. 30, 1976. See Text-figure 1, locality 8, for geographic location.

25726-PC.—Winifrede Limestone of Hennen (1914), borehole No. 7 (USGS core No. IC-76-2), core sample of medium- to dark-gray calcareous shale from 62.18 m (204 ft) to 63.09 m (207 ft) below surface (and base of Coalburg coal bed), west side of Gauley Mountain above Schoolhouse Branch (map elevation 1,586 ft), about 1,524 m (5,000 ft) east of Beech Glen and 1,981.2 m (6,500 ft) north of Alta, NE¼ Gauley Bridge 7½ minute quadrangle, Fayette County. Collected by H. H. Arndt, Apr. 30, 1976. See Text-figure 1, locality 7, for geographic location.

25727-PC.—Winifrede Limestone of Hennen (1914), borehole No. 8 (USGS core No. IC-76-4), core sample of medium- to dark-gray calcareous shale (grades to argillaceous limestone) from 61.42 m (201.5 ft) to 62.42 m (204.8 ft) below surface (and base of Coalburg coal bed), north end of Gauley Mountain (map elevation 1,548 ft), about 2,286 m (7,500 ft) east of Beech Glen and 1,371.6 m (4,500 ft) southeast of Belva, NE¼ Gauley Bridge 7½ minute quadrangle, Fayette County. Collected by H. H. Arndt, Apr. 30, 1976. See Text-figure 1, locality 6, for geographic location.

**Kentucky**

12920-PC (LC-2).—Shale about 4.6 m (15 ft) above strip bench of Hindman coal, in the highwall. About 3.2 km (2 mi) north of Hindman and 1,207 m (4,000 ft) northeast of Ogden, due north of hill with 1,764 ft elevation. NW corner of Hindman 7½ minute quadrangle, on divide between Trace Branch and Sandlick Branch, Knott County. Collected by C. L. Rice (E&R KG-75-2).

12923-PC (LC4-8).—Shale just above limestone, 0.46 m (18 in) above 0.15 m (6 in) of black shale overlying the Hindman coal bed. On strip bench at an elevation of 522.7 m (1,715 ft) on divide between John Creek and Camp Creek of Middle Fork of Kentucky River, 548.6 m (1,800 ft) northwest of hill marked 1,725 ft, Cutshin 7½ minute quadrangle, Leslie County. Collected by C. L. Rice (E&R KG-75-5).

12926-PC (LC5-5).—Shale above "Lost Creek Limestone." Strip bench 532.5 m (1,747 ft) elevation, on divide between Lower Bed Creek and Camp Creek of the Middle Fork of the Kentucky River. In saddle between hill marked 1,870 ft and the hill to the south on Cutshin 7½ minute quadrangle, Leslie County. Collected by C. L. Rice, July 20, 1975 (E&R KG-75-5).

12927-PC (LC6-1).—Shale about 0.9 m (3 ft) above Hindman coal. Strip bench at 567 m (1,860 ft) elevation, at head of Raccoon Creek, 609.6 m (2,000 ft) southeast of BM 1472, Cutshin 7½ minute quadrangle, Leslie County. Collected by C. L. Rice (E&R KG-75-5).

12948-PC (KB-66).—Shale in Tradewater Formation above its Mining City coal bed below its Curlew Limestone Member (Atokan). At milepost 29, Green River Parkway, approx. 4 km (2.5 mi) west of Morgantown, 1.62 km (5,300 ft) north of boundary, and 1.68 km (5,500 ft) west of boundary of Morgantown 7½ minute quadrangle, Butler County. Collected by John Beard (E&R Coal-79-7).

21413-PC (NB F2S).—"Magoffin beds" of Breathitt Formation. Roadcut on north side of Kentucky Hwy. 80, at a point due north of junction of Rockhouse Creek with small southeast-flowing stream near longitude 83°27′30″ W. in southwest part of Hyden West 7½ minute quadrangle, Leslie County. Collected by V. M. Seiders, 1963 (E&R KG-64-4).

21604-PC.—Top of Kendrick Shale. Lick Creek 7½ minute quadrangle, on divide between Hurricane Creek and west branch of left fork of Grapevine Creek. Located midway between the apices of 1,720-foot contours; also, above (northeast of) the head of a small tributary of Hurricane Creek at latitude 37°27′15″ N. 0.56 km (0.35 mi) west southwest of BM 1,130, Pike County. Collected by S. C. Bergman, Feb. 1964 (E&R KG-64-23).

12974-PC (KB-5-1).—Clayey shale 0.15 m (6 in) directly below 0.91 m (3 ft) thick Curlew Limestone Member (upper Atokan) of the Tradewater Formation, which is approx. 6.1 m (20 ft) above the No. 4 coal bed, 152 m (500 ft) from north line of Morgantown 7½ minute quadrangle boundary and 5.64 km (18,500 ft) from east line of quadrangle (Gildersleeve, 1972). West side of US Hwy. 231, approx. 183 m (600 ft) N of north end of bridge over Green River, approx. 2.24 km (1.4 mi) north of Morgantown, Butler County. Collected by T. M. Kehn (E&R KG-75-7). (= loc. Ky-2 of Thompson and Riggs (*in* Thompson, Shaver, and Riggs, 1959, p. 775); loc. 62 of Thompson and Shaver (1964, p. 12)).

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PLATES

## EXPLANATION OF PLATE 1

Figure — Page

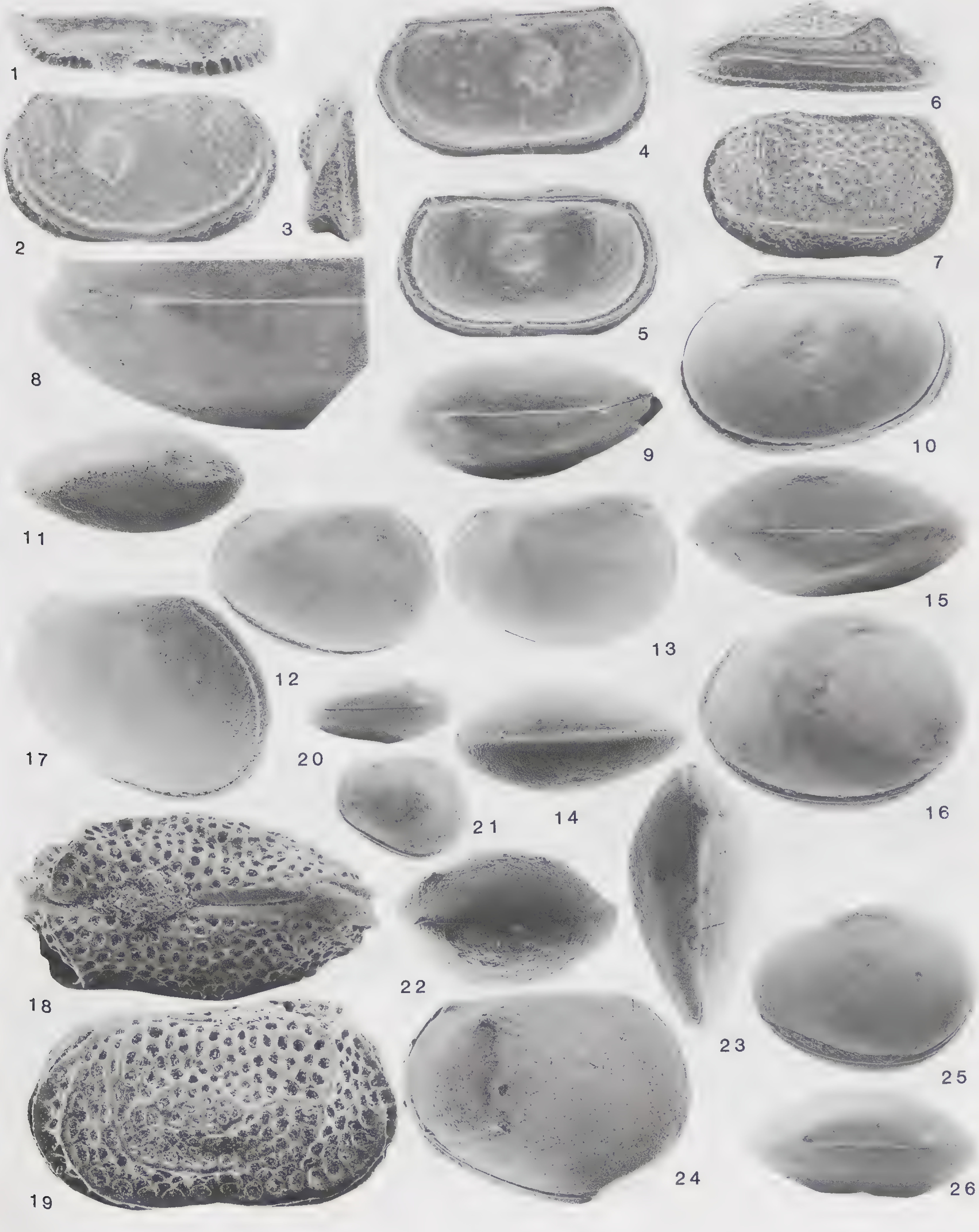
1–4. **Amphissites (Amphissites)** sp. aff. **A. robertsi** Morey, 1935 ........ 12
Figured specimen: USNM 325027. USGS colln. 25727-PC. Dorsal (anterior to left), outside, posterior, and inside views of left valve, approx. ×60.

5–7. **Amphissites (Amphikegelites) henryi** new species ........ 12
Paratype: USNM 325078. USGS colln. 25725-PC. Inside, dorsal, and outside views of right valve, approx. ×60.

8–17. **Shishaella saundersi** new species ........ 20
- 8–10. Paratype: USNM 325070. USGS colln. 12971-PC. 8. Detail of dorsoposterior, to show spine on right valve, approx. ×80. 9–10. Dorsal view, and view of steinkern of left valve as well as hinge and overlap of right valve of adult specimen with left valve missing, approx. ×40.
- 11, 12. Paratype: USNM 325071. USGS colln. 12971-PC. Dorsal and right views of probably subadult carapace, approx. ×40.
- 13, 14. Paratype: USNM 325072. USGS colln. 12971-PC. Right and ventral (anterior to right) views of young growth stage, approx. ×67.
- 15, 16. Holotype: USNM 325069. USGS colln. 12971-PC. Dorsal (anterior to right) and right views of adult carapace, approx. ×40. (See also Pl. 5, figs. 24, 25.)
- 17. Paratype: USNM 325073. USGS colln. 12971-PC. Right anterior oblique view of subadult carapace, approx. ×67.

18, 19. **Kegelites** sp. ........ 14
Figured Specimen: USNM 331632. USGS colln. 25682-PC. Dorsal and left views of carapace, approx. ×67.

20–26. **Shishaella saundersi** new species ........ 20
- 20, 21. Paratype: USNM 325074. USGS colln. 12971-PC. Dorsal and right views of carapace of young growth stage, approx. ×40.
- 22–24. Paratype: USNM 325075. USGS colln. 12971-PC. Posterior (dorsal to left), dorsal (posterior up), and right views of carapace of a young growth stage, approx. ×80.
- 25, 26. Paratype: USNM 325076. USGS colln. 12971-PC. Dorsal and right views of carapace of subadult growth stage, approx. ×40.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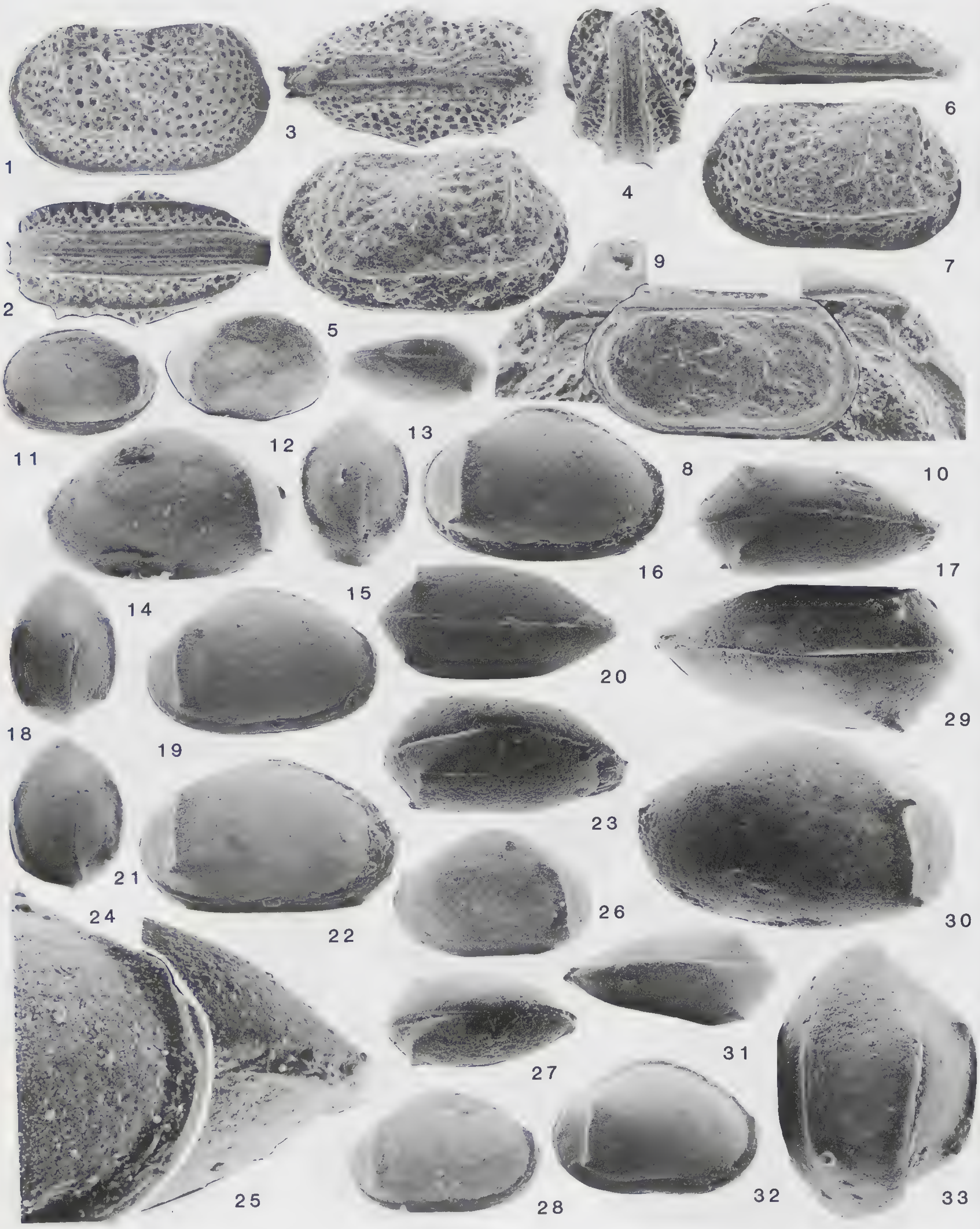
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## Explanation of Plate 2

Figure Page

1–10. **Amphissites (Amphikegelites) henryi** new species ........ 12

1–4. Holotype: USNM 325029. USGS colln. 26774-PC. Right, ventral, dorsal, and posterior views of carapace, approx. ×60.

5. Paratype: USNM 325030. USGS colln. 12971-PC. Outside view of left valve, approx. ×67.

6–10. Paratype: USNM 325031. USGS colln. 26774-PC. 6–9. Dorsal, outside, and inside views of left valve, approx. ×60. 10. Details of terminal hingement approx. ×200.

11–13. **Cavellinella? pricei** new species ........ 30

Paratype: USNM 325163. USGS colln. 12971-PC. Left, right, and dorsal views of young growth stage, approx. ×67.

14–33. **Healdia ehlersi** Bradfield, 1935 ........ 26

14–17. Figured Specimen: USNM 325133. USGS colln. 12971-PC. Left, posterior, right, and dorsal views of carapace, approx. ×80.

18–20. Figured Specimen: USNM 325134. USGS colln. 26774-PC. Posterior, right, and ventral views of carapace, approx. ×80.

21–23. Figured Specimen: USNM 325135. USGS colln. 26774-PC. Posterior, right, and dorsal views of carapace, approx. ×80.

24–28. Figured Specimen: USNM 325136. USGS colln. 12971-PC. 24. Detail of anterior of right valve, approx. ×240. 25. Detail of dorsoanterior, approx. ×220. 26–28. Left, dorsal, and right views of carapace, approx. ×67.

29, 30. Figured Specimen: USNM 325137. USGS colln. 25669-PC. Dorsal, and left views of carapace, approx. ×100.

31–33. Figured Specimen: USNM 325138. USGS colln. 12971-PC. 31, 32. Dorsal and right views of carapace, approx. ×67. 33. Posterior view, approx. ×133.

## EXPLANATION OF PLATE 3

Figure — Page

1–15. **"Microparaparchites" reductospinosus** new species .......... 18

1, 2. Paratype: USNM 325044. USGS colln. 12971-PC. Dorsal and left views of carapace, young growth stage, approx. ×80.

3–5. Paratype: USNM 325045. USGS colln. 26774-PC. Dorsal, outside, and inside views of left valve, juvenile approx. ×60.

6–8. Paratype: USNM 325046. USGS colln. 12971-PC. Right, dorsal, and left views of carapace, young growth stage, approx. ×66.

9, 10. Paratype: USNM 325047. USGS colln. 25690-PC. Dorsal and right views of right valve, juvenile, approx. ×66.

11, 12. Paratype: USNM 325048. USGS colln. 12971-PC. Dorsal and left views of carapace, juvenile, approx. ×80.

13–15. Paratype: USNM 325049. USGS colln. 26774-PC. Dorsal, outside, and inside views of left valve, juvenile approx. ×60.

16, 17. **Pseudoparaparchites** spp. .......... 17

Figured Specimen: USNM 325042. USGS colln. 25656-PC. Left and dorsal views of carapace approx. ×100.

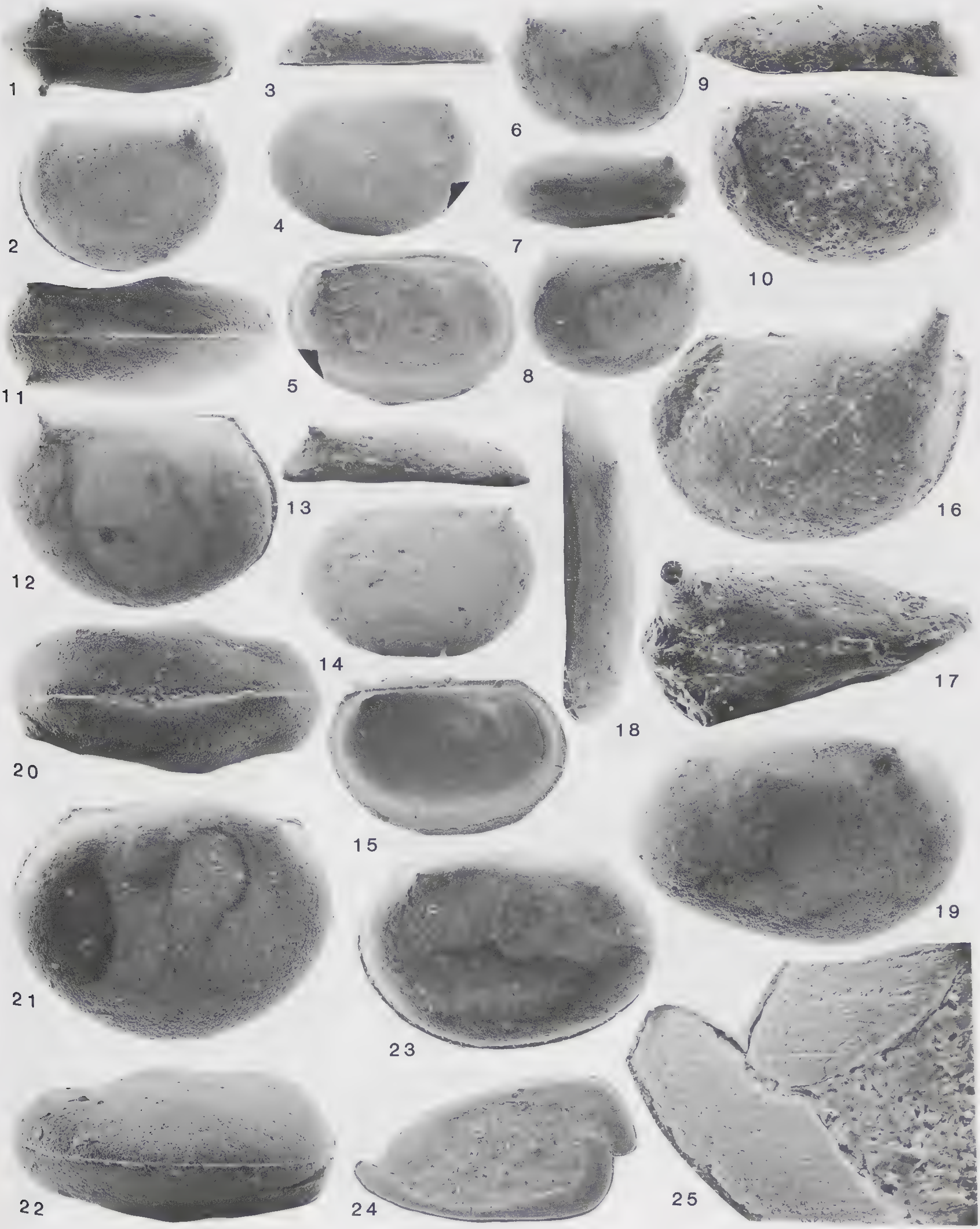
18–25. **"Microparaparchites" reductospinosus** new species .......... 18

18, 19. Paratype: USNM 325050. USGS colln. 12971-PC. Dorsal (posterior on top) and outside views of left valve, adult, approx. ×66.

20–22. Paratype: USNM 325051. USGS colln. 12971-PC. Dorsal (anterior to right), left, and ventral views, subadult carapace, approx. ×80.

23. Holotype: USNM 325043. USGS colln. 12971-PC. Right view of carapace, adult, approx. ×60.

24, 25. Paratype: USNM 325052. USGS colln. 12971-PC. 24. Polished surface toward anterior in front of midlength of probably subadult carapace, approx. ×80. 25. Detail of ventral contact to show absence of inner lamella, approx. ×400.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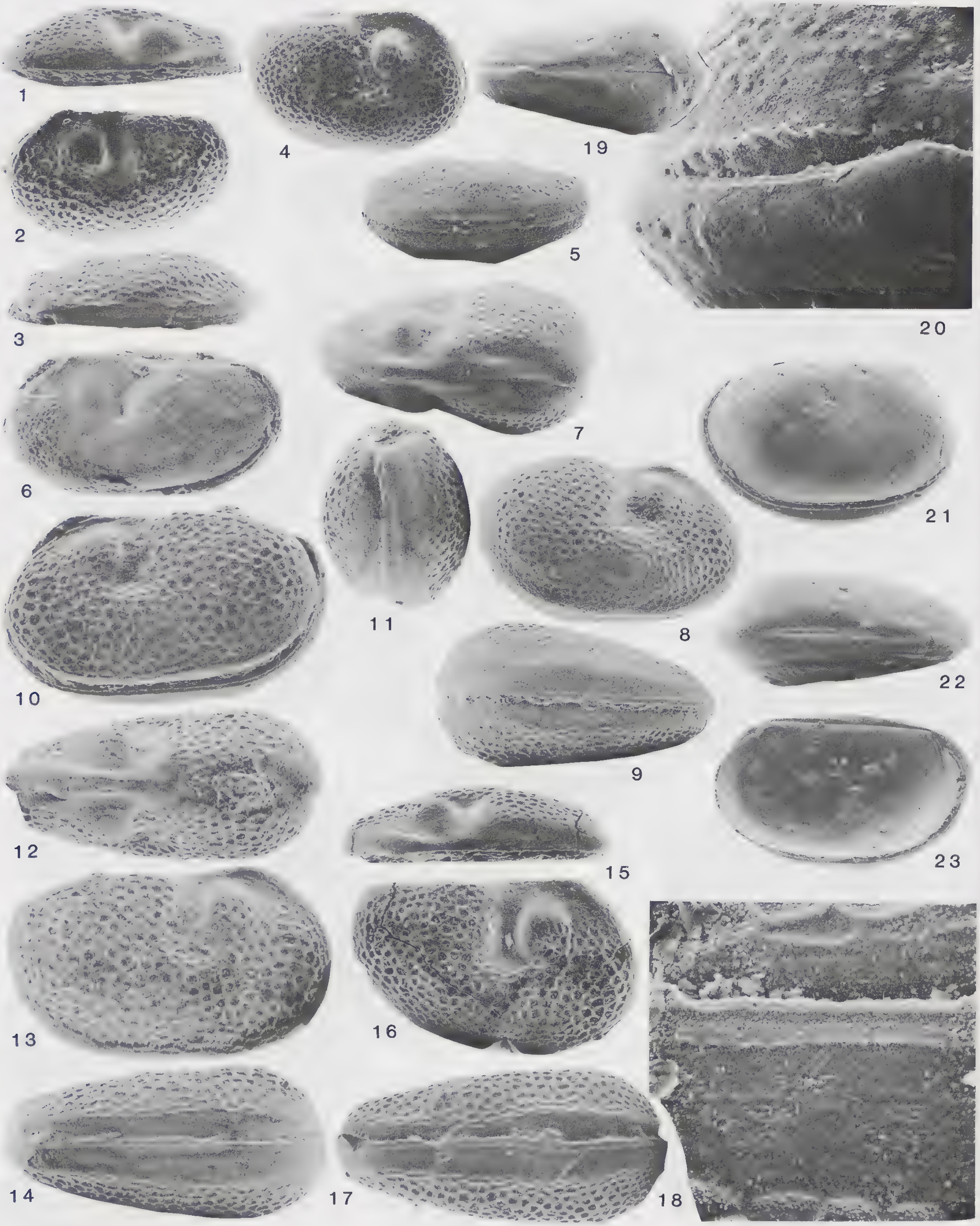
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## EXPLANATION OF PLATE 4

Figure — Page

1–18. **Plavskella englundi** new species .......... 21

1–3. Paratype: USNM 325081. USGS colln. 12971-PC. Dorsal (anterior to right), outside, and ventral (anterior to left) views of left valve, young growth stage, approx. ×80. Note smooth area along venter.

4, 5. Paratype: USNM 325082. USGS colln. 12971-PC. Right and ventral (anterior to right) views of carapace, larger growth stage than stage shown in figures 1–3, approx. ×67.

6. Paratype: USNM 325083. USGS colln. 26774-PC. Left view of abraded carapace of young growth stage showing some of the reticulations preserved, approx. ×80.

7–9. Holotype: USNM 325080. USGS colln. 12971-PC. Dorsal, right, and ventral views of adult carapace, female, approx. ×67.

10–14. Paratype: USNM 325084. USGS colln. 12971-PC. Left, posterior, dorsal, right, and ventral views of carapace of either adult or subadult male, approx. ×80.

15, 16. Paratype: USNM 325085. USGS colln. 26774-PC. Dorsal and outside views of right valve, juvenile, approx. ×80.

17, 18. Paratype: USNM 325086. USGS colln. 26774-PC. Ventral view and detail of part of ventral surface to show that the smooth surface is not due to preservation, approx. ×400.

19–23. **Sansabella stewartae** Marple, 1952 .......... 19

19–21. Figured Specimen: USNM 325057. USGS colln. 26774-PC. 19. Dorsal view, approx. ×60. 20. Detail of dorsoanterior to show spinelets on overlapped valve, approx. ×320. 21. Right view of carapace, approx. ×60.

22, 23. Figured Specimen: USNM 325058. USGS colln. 26774-PC. Dorsal and left views of carapace with the hingement and overlap reversed, approx. ×60.

## EXPLANATION OF PLATE 5

Figure | Page
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1–9. **Bairdiacypris** cf. **B. rectiformis** (Shaver, 1959) .......... 24

1–5. Figured Specimen: USNM 325106. USGS colln. 12971-PC. Right, ventral (anterior to left), dorsal (anterior to left), left, and posterior views of subadult carapace, approx. ×40.

6–9. Figured Specimen: USNM 325107. USGS colln. 12971-PC. Posterior, dorsal (anterior to left), right, and ventral (anterior to left) views of carapace, juvenile, approx. ×40.

10–16. **Amphissites (Amphikegelites) henryi** new species .......... 12

10. Paratype: USNM 325032. USGS colln. 25725-PC. Outside view of left valve, approx. ×60.

11–12. Paratype: USNM 325033. USGS colln. 25727-PC. Dorsal and lateral views of left valve, early growth stage, approx. ×60.

13, 14. Paratype: USNM 325034. USGS colln. 25727-PC. Left and right views of adult carapace, approx. ×60.

15, 16. Paratype: USNM 325030 (same specimen as that shown in Pl. 2, fig. 5). USGS colln. 12971-PC. Dorsal and ventral views of left valve, approx. ×67.

17, 18. **A. (Amphikegelites)** new species A .......... 13

Figured Specimen: USNM 325041. USGS colln. 12917-PC. Dorsal and left views of adult carapace, approx. ×67.

19, 20. **Bairdia isoscelata** Shaver, 1959 .......... 22

Figured Specimen: USNM 325096. USGS colln. 12917-PC. Dorsal (anterior to left) and right views of carapace with the posterior missing, approx. ×40.

21–23. **Cavellinella? pricei** new species .......... 30

Paratype: USNM 325164. USGS colln. 12971-PC. Left, dorsal (anterior to left), and posterior views of carapace, probably male, approx. ×60.

24–29. **Shishaella saundersi** new species .......... 20

24, 25. Holotype: USNM 325069 (same specimen as that shown in Pl. 1, figs. 15, 16). USGS colln. 12971-PC. Left and posterior views of carapace, approx. ×40.

26–29. Paratype: USNM 325077. USGS colln. 12971-PC. Right, dorsal (anterior to right), posterior, and left views of adult carapace, approx. ×33.

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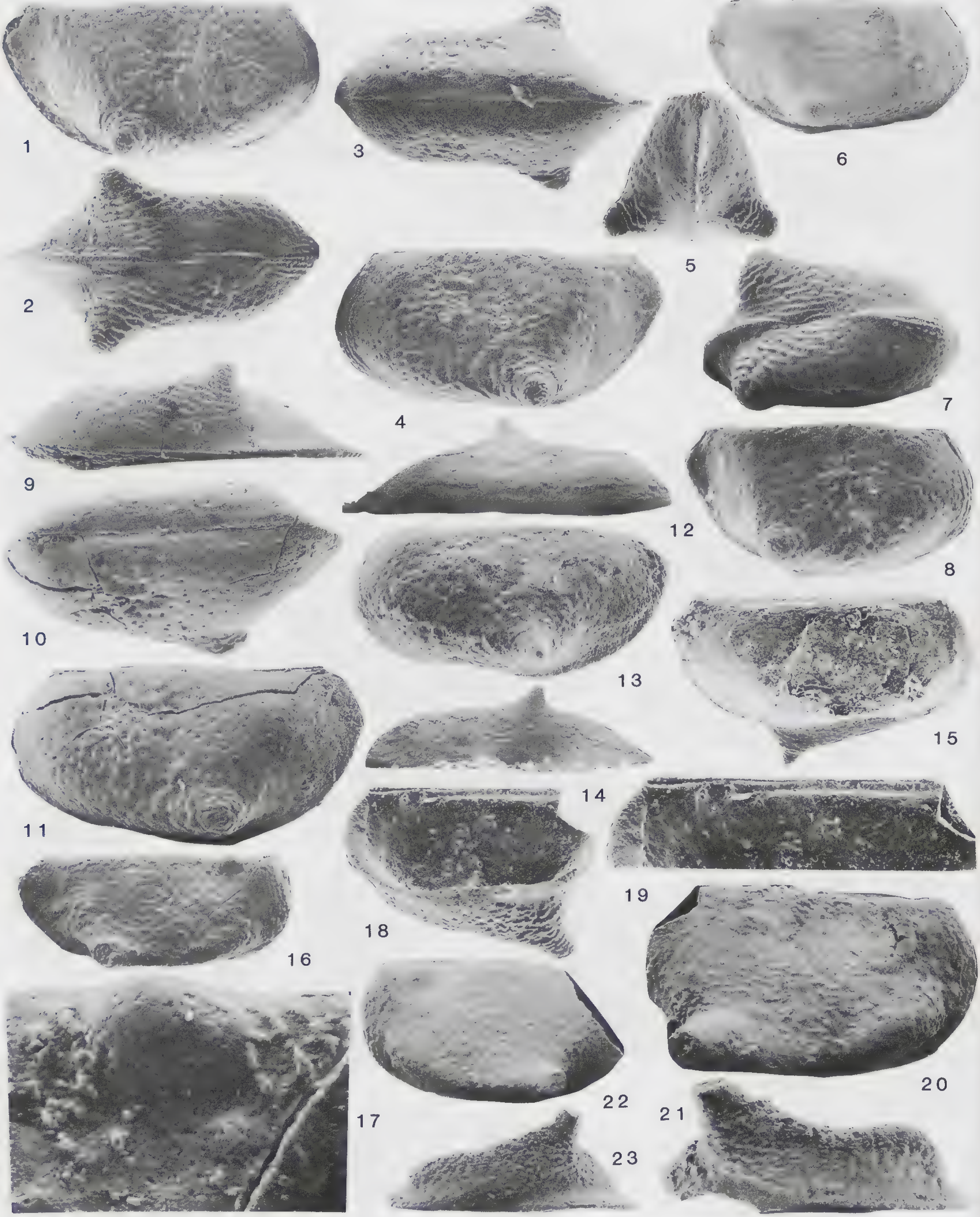
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## EXPLANATION OF PLATE 6

Figure Page

1–15. **Monoceratina winifredeana** new species ........ 25

1–5. Holotype: USNM 325117. USGS colln. 12971-PC. Right, ventral, dorsal, left, and posterior views of carapace, approx. ×80.

6. Paratype: USNM 325118. USGS colln. 12971-PC. Right view of carapace, small individual, approx. ×80.

7, 8. Paratype: USNM 325119. USGS colln. 25665-PC. Anteroventral oblique and right views of carapace, approx. ×80. Figure 7 is foreshortened because of angle of orientation.

9. Paratype: USNM 325120. USGS colln. 12971-PC. Ventral view of left valve, approx. ×80.

10, 11. Paratype: USNM 325121. USGS colln. 12971-PC. Dorsal and left views of carapace, adult, approx. ×80.

12–15. Paratype: USNM 325122. USGS colln. 12917-PC. Dorsal, lateral, ventral, and inside views of left valve, approx. ×66.

16–23. **Monoceratina** sp. aff. **M. macoupeni** Scott and Borger, 1941 ........ 26

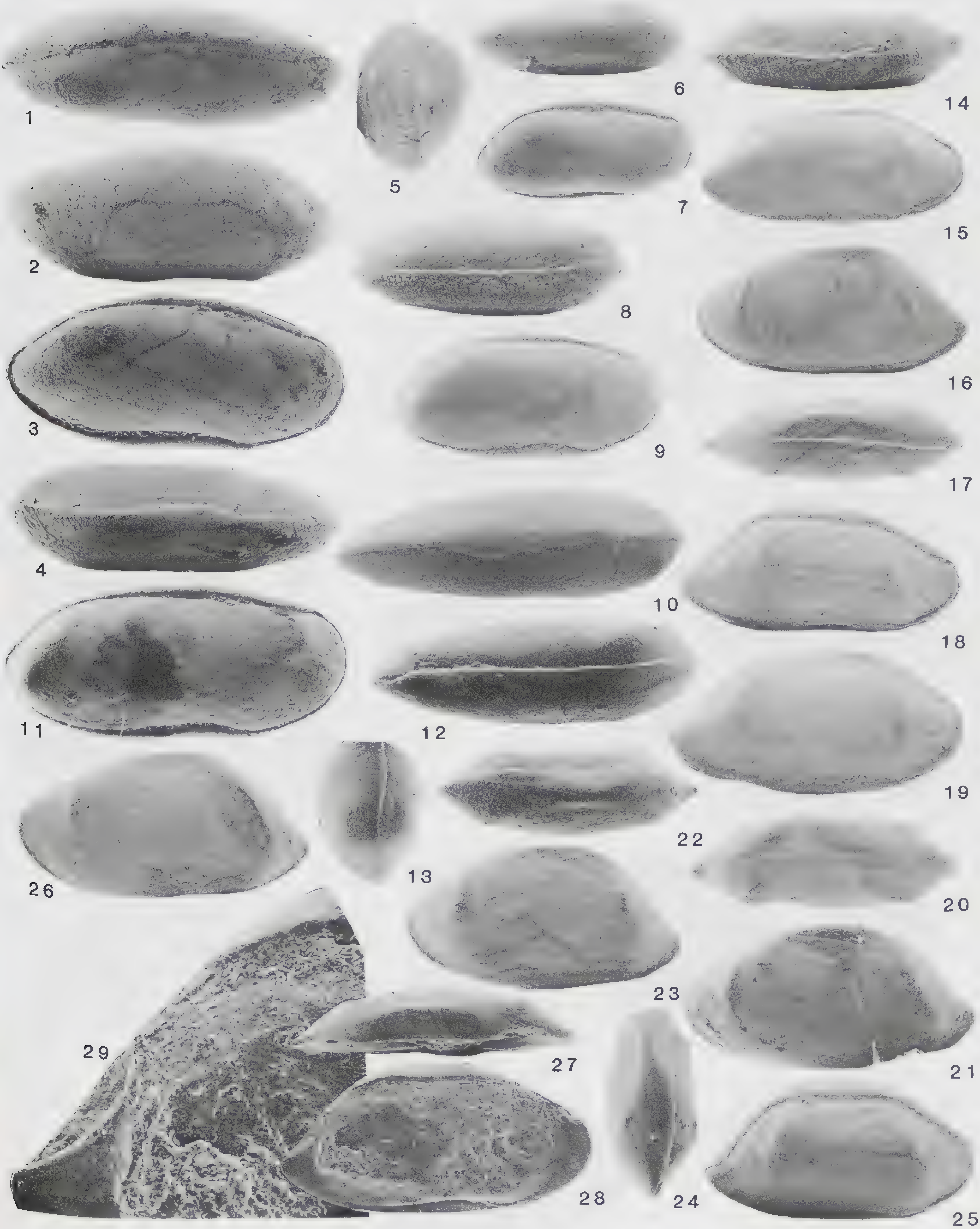
16, 17. Figured Specimen: USNM 325128. USGS colln. 25726-PC. Lateral view of left valve, approx. ×60, and detail of dorsoanterior node to show that the node is part of the shell, approx. ×400.

18–21. Figured Specimen: USNM 325129. USGS colln. 12917-PC. 18. Inside view, approx. ×66. 19–21. Detail of hinge, and outside and ventral views of right valve with missing dorsoposterior, approx. ×100.

22, 23. Figured Specimen: USNM 325130. USGS colln. 12917-PC. Outside and ventral views of left valve with missing posterior, approx. ×66.

## EXPLANATION OF PLATE 7

| Figure | | Page |
|---|---|---|
| 1–13. | **Bairdiacypris** cf. **B. rectiformis** (Shaver, 1959) | 24 |
| | 1–5. Figured Specimen: USNM 325108. USGS colln. 12971-PC. Dorsal (anterior to right), left, right, ventral (anterior to right), and posterior views, adult carapace, approx. ×50. | |
| | 6, 7. Figured Specimen: USNM 325109. USGS colln. 12971-PC. Dorsal (anterior to left) and right views, younger growth stage, approx. ×33. | |
| | 8, 9. Figured Specimen: USNM 325110. USGS colln. 12971-PC. Dorsal (anterior to left) and right views of adult carapace, approx. ×40. | |
| | 10–13. Figured Specimen: USNM 325111. USGS colln. 12971-PC. Ventral (anterior to left), right, dorsal (anterior to left), and posterior views, adult carapace, approx. ×50. | |
| 14–29. | **Bairdiolites astigmaticus** new species | 23 |
| | 14, 15. Paratype: USNM 325099. USGS colln. 12971-PC. Dorsal (anterior to left) and right views, adult carapace, approx. ×40. | |
| | 16–18. Paratype: USNM 325100. USGS colln. 12971-PC. 16, 18. Left and right views of adult carapace, approx. ×40; 17. dorsal (anterior to right) of same carapace, approx. ×57. | |
| | 19–21. Paratype: USNM 325101. USGS colln. 12971-PC. Right, dorsal (anterior to left), and left views, adult carapace, approx. ×40. | |
| | 22–25. Holotype: USNM 325098. USGS colln. 12971-PC. Dorsal (anterior to left), left, posterior oblique, and right views, adult carapace, approx. ×40. | |
| | 26–29. Paratype: USNM 325102. USGS colln. 12971-PC. 26–28. Left, dorsal (anterior to right), inside views of left valve, approx. ×40. 29. Detail of posterior, approx. ×130. | |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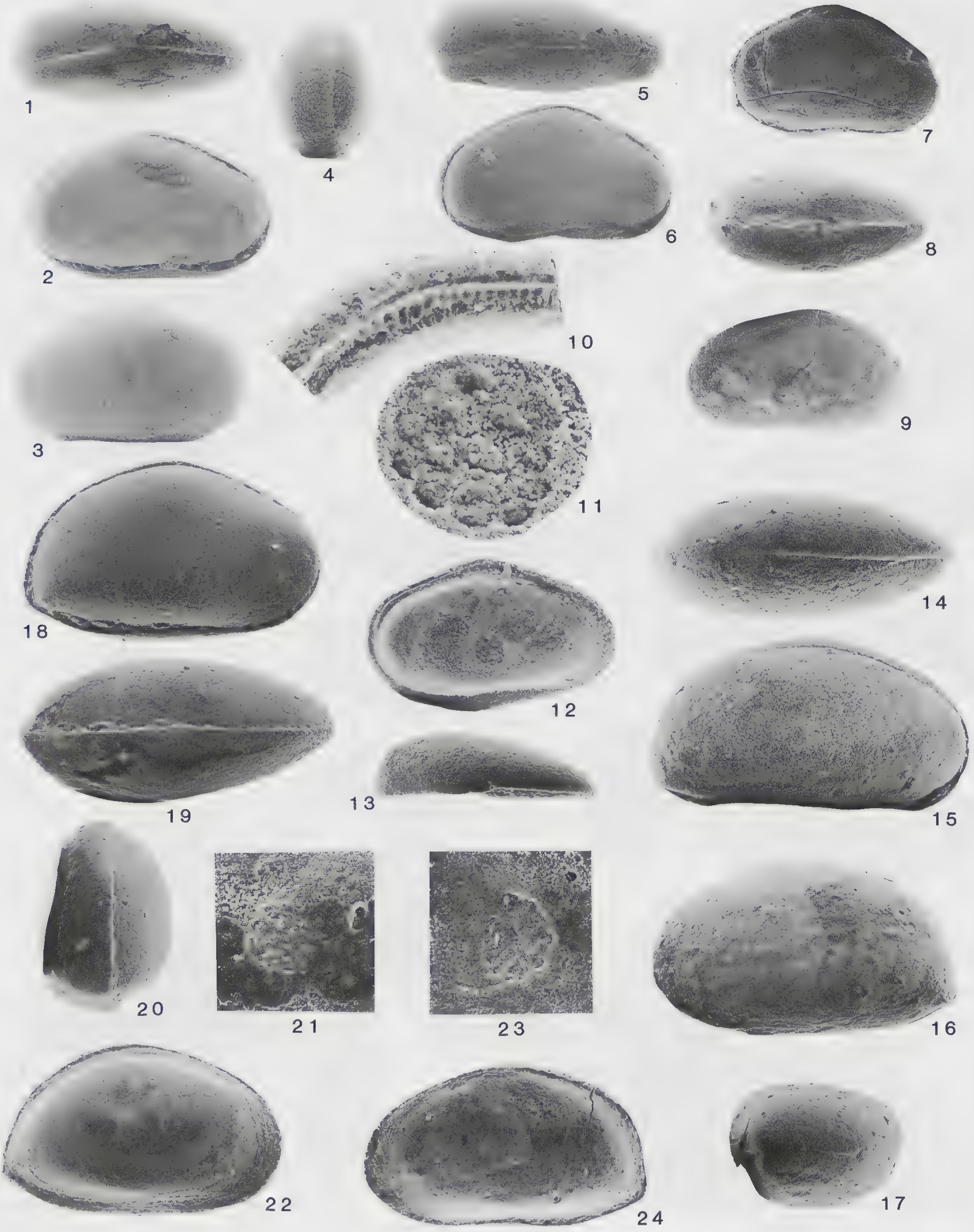
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## Explanation of Plate 8

Figure Page

1–13. **Pseudobythocypris? enigmatica** new species ........ 28

1–4. Holotype: USNM 325149. USGS colln. 12971-PC. Dorsal (anterior to right), right, left and posterior views of carapace, approx. ×80.

5, 6. Paratype: USNM 325150. USGS colln. 26774-PC. Dorsal (anterior to right) and left views of carapace, approx. ×80.

7–9. Paratype: USNM 325151. USGS colln. 26774-PC. Right, ventral (anterior to right), and left views of carapace, younger individual, approx. ×80.

10–13. Paratype: USNM 325152. USGS colln. 12971-PC. 10. Detail of dorsoposterior part of hinge approx. ×433. 11. Detail of adductor-muscle-attachment scar, approx. ×477. 12, 13. Inside and dorsal (anterior to right) views of left valve, young individual, approx. ×80.

14–24. **Pseudobythocypris pediformis** (Knight, 1928) ........ 28

14–17. Figured Specimen: USNM 325145. USGS colln. 26774-PC. Dorsal (anterior to right), right, left, and posterior views of carapace, approx. ×80.

18–20. Figured Specimen: USNM 325146. USGS colln. 26774-PC. Right, ventral (anterior to right), and posterior views of carapace, approx. ×80. The left side of specimen shown in figure 20 was inadvertently covered by mounting medium for microphotography.

21, 22. Figured Specimen: USNM 325147. USGS colln. 12971-PC. 21. Detail of adductor-muscle-attachment scars, approx. ×200. 22. Inside of left valve of an individual younger than the one shown in figs. 14–17, approx. ×80.

23, 24. Figured Specimen: USNM 325148. USGS colln. 12971-PC. 23. Detail of adductor-muscle-attachment scars, approx. ×200. 24. Inside of right valve, approx. ×80.

## EXPLANATION OF PLATE 9

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1–23. **Cavellinella? pricei** new species ........ 30

1–4. Holotype: USNM 325156. USGS colln. 12971-PC. Dorsal (anterior to left), posterior, left, and ventral (anterior to right), views of carapace, probably a female, approx. ×60.

5, 6. Paratype: USNM 325157. USGS colln. 12971-PC. Posterior and right views of carapace slightly crushed in the anterior half, probably a male, approx. ×50.

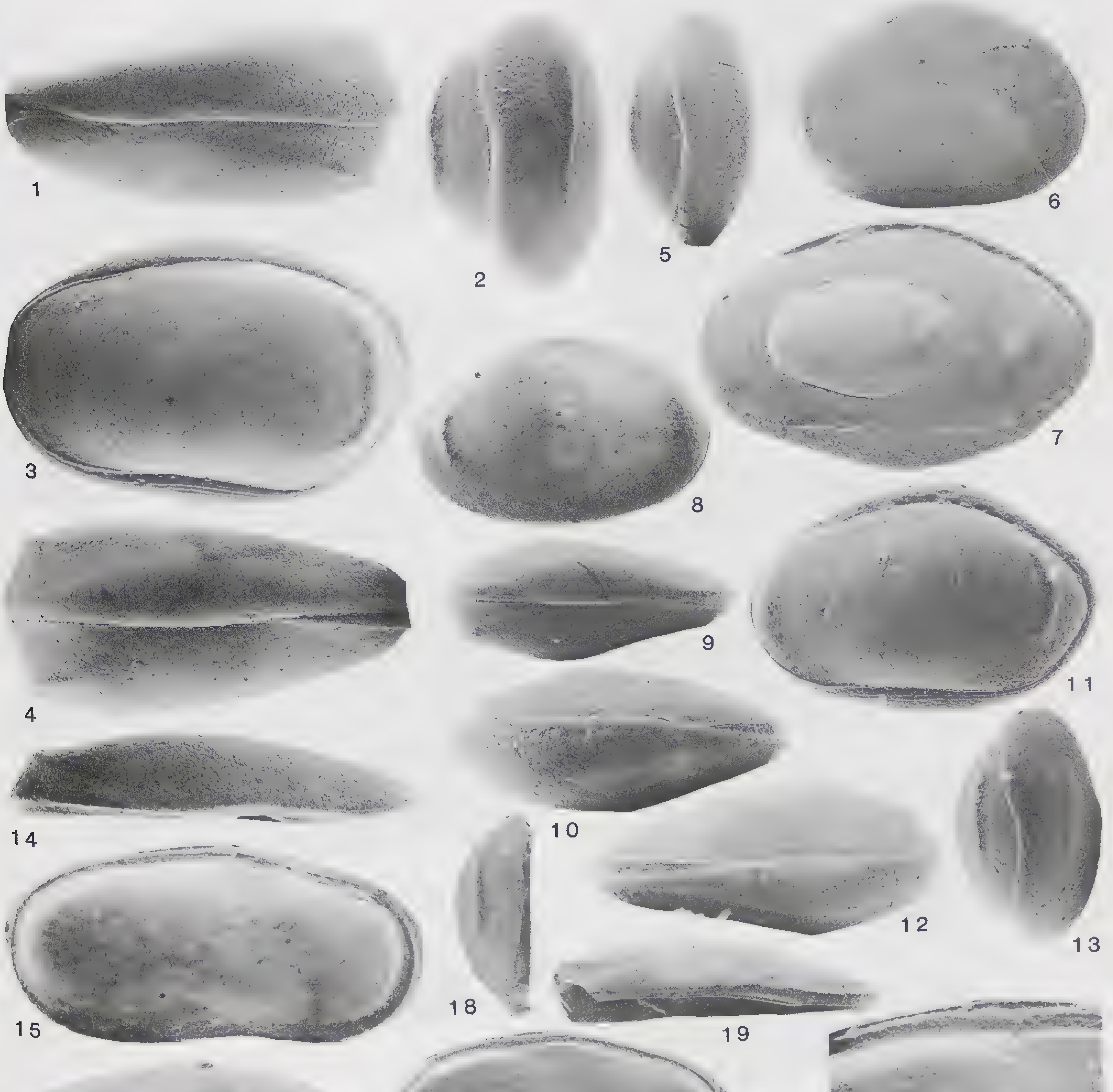
7. Paratype: USNM 325158. USGS colln. 12971-PC. Left view of very young instar approx. ×60, superposed on the same view, approx. ×120, for comparison with other stages of growth.

8, 9. Paratype: USNM 325159. USGS colln. 12971-PC. Right and ventral (anterior to right), views of carapace of a young growth stage, approx. ×60.

10–13. Paratype: USNM 325160. USGS colln. 12971-PC. Dorsal (anterior to right), left, ventral, (anterior to left), and posterior views of carapace, subadult? stage, approx. ×60.

14–18. Paratype: USNM 325161. USGS colln. 12971-PC. 14, 15. Dorsal (anterior to right) and inside views of left valve, male, approx. ×60. 16, 17. Outside and ventral views (anterior to left), approx. ×53. 18. Posterior, approx. ×60.

19–23. Paratype: USNM 325162. USGS colln. 12971-PC. 19–22. Dorsal (anterior to right), inside, outside, and posterior views of left valve (female), approx. ×50. 23. Detail of posterior part to show internal septum indicative of female, approx. ×100.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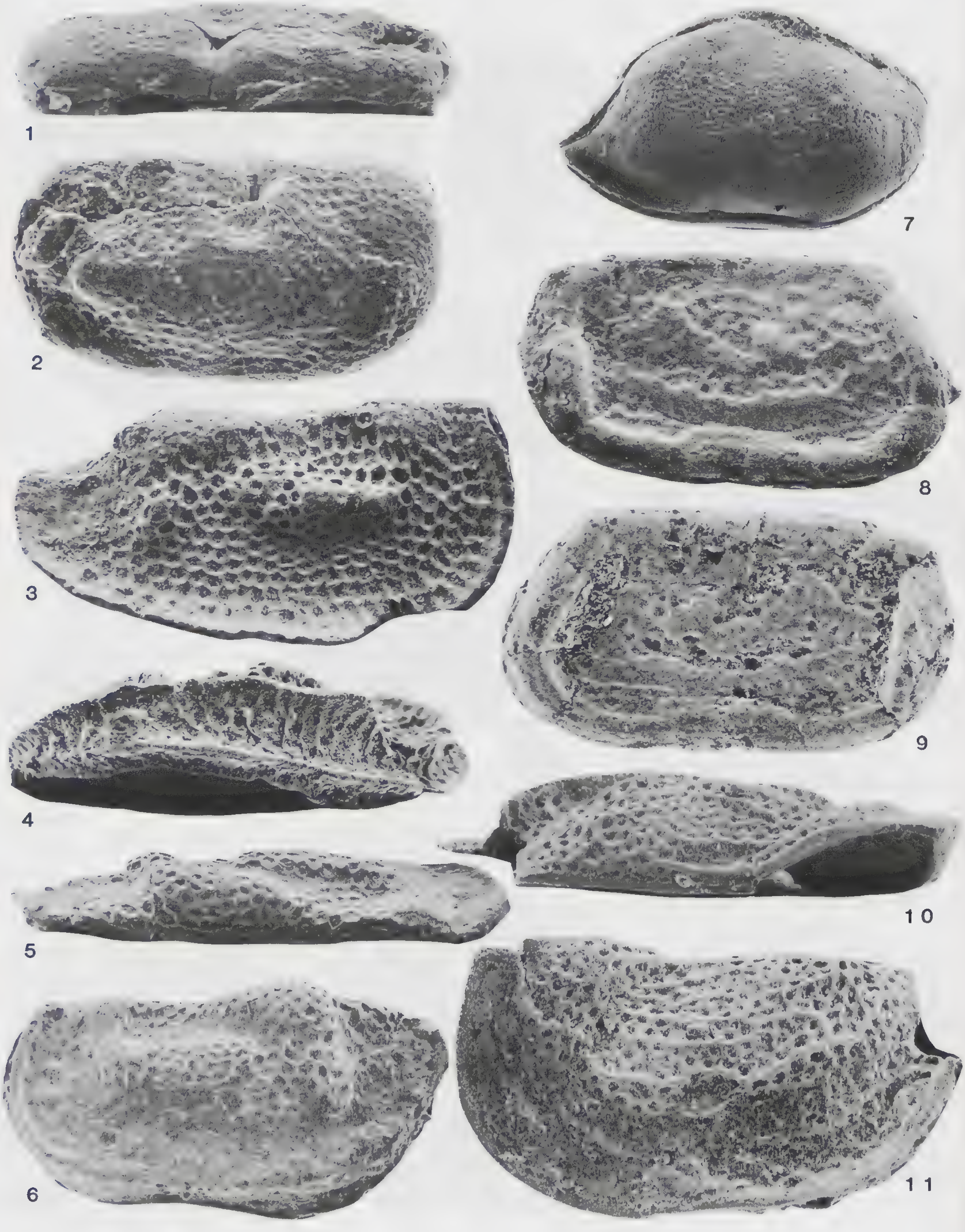
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## Explanation of Plate 10

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1, 2. **Kirkbyella (Berdanella) ricei** new species ........ 15
Paratype: USNM 331614. USGS colln. 25669-PC. Dorsal and outside views of broken left valve, approx. ×100.

3–6. **Aurikirkbya** spp. ex gr. **A. triseriata** Shaver, 1959 ........ 14
3, 4. Figured Specimen: USNM 331101. USGS colln. 12910-PC. Outside and ventral views of right valve, approx. ×75.
5, 6. Figured Specimen: USNM 331102. USGS colln. 12917-PC. Dorsal and outside views of left valve, approx. ×75.

7. **Orthobairdia oklahomaensis** (Harlton, 1927) ........ 22
Figured Specimen: USNM 331113. USGS colln. 25669-PC. Right view of carapace, approx. ×55.

8, 9. **Moorites minutus** (Warthin, 1930)? ........ 16
Figured Specimen: USNM 331111. USGS colln. 25656-PC. Right and left views of crushed carapace, approx. ×150.

10, 11. **Kirkbya magna** Roth *sensu* Cooper, 1946 ........ 15
Figured Specimen: USNM 331107. USGS colln. 25660-PC. Dorsal (anterior to right) and outside views of broken left valve, approx. ×100.

## EXPLANATION OF PLATE 11

(Except where noted, all specimens are from the Middle Pennsylvanian of Kentucky.)

Figure ... Page

1\. **Healdia ehlersi** Bradfield, 1935 ... 26
Figured Specimen: USNM 168223. USGS colln. 12948-PC. Right view of carapace, approx. ×120.

2–4\. **Moorites** spp. ... 16
2\. Figured Specimen: USNM 331103. USGS colln. 12927-PC. Outside view of left valve, approx. ×75.
3, 4. Figured Specimen: USNM 331104. USGS colln. 12920-PC. Dorsal (anterior to left) and outside views of right valve, approx. ×150.

5, 6. **Aurikirkbya** spp. ex gr. **A. triseriata** Shaver, 1959 ... 14
5\. Figured Specimen: USNM 331105. USGS colln. 12974-PC. Right view of juvenile carapace, approx. ×103.
6\. Figured Specimen: USNM 331106. USGS colln. 12926-PC. Right view of carapace, approx. ×75.

7–9\. **Monoceratina winifredeana** new species ... 25
Figured Specimen: USNM 325127. USGS colln. 21413-PC. Dorsal (anterior to left), right, and ventral (anterior to left) views of carapace, approx. ×30.

10\. **Monoceratina** sp. aff. **M. macoupeni** Scott and Borger, 1941 ... 26
Figured Specimen: USNM 168219. USGS colln. 21413-PC. Outside view of left valve, approx. ×30.

11, 12. **Monoceratina ardmorensis** (Harlton, 1927) ... 25
Holotype: USNM 71402. Lower part of "Glenn Formation," Love County, Oklahoma. Left and ventral (anterior to left) views of carapace, approx. ×30.

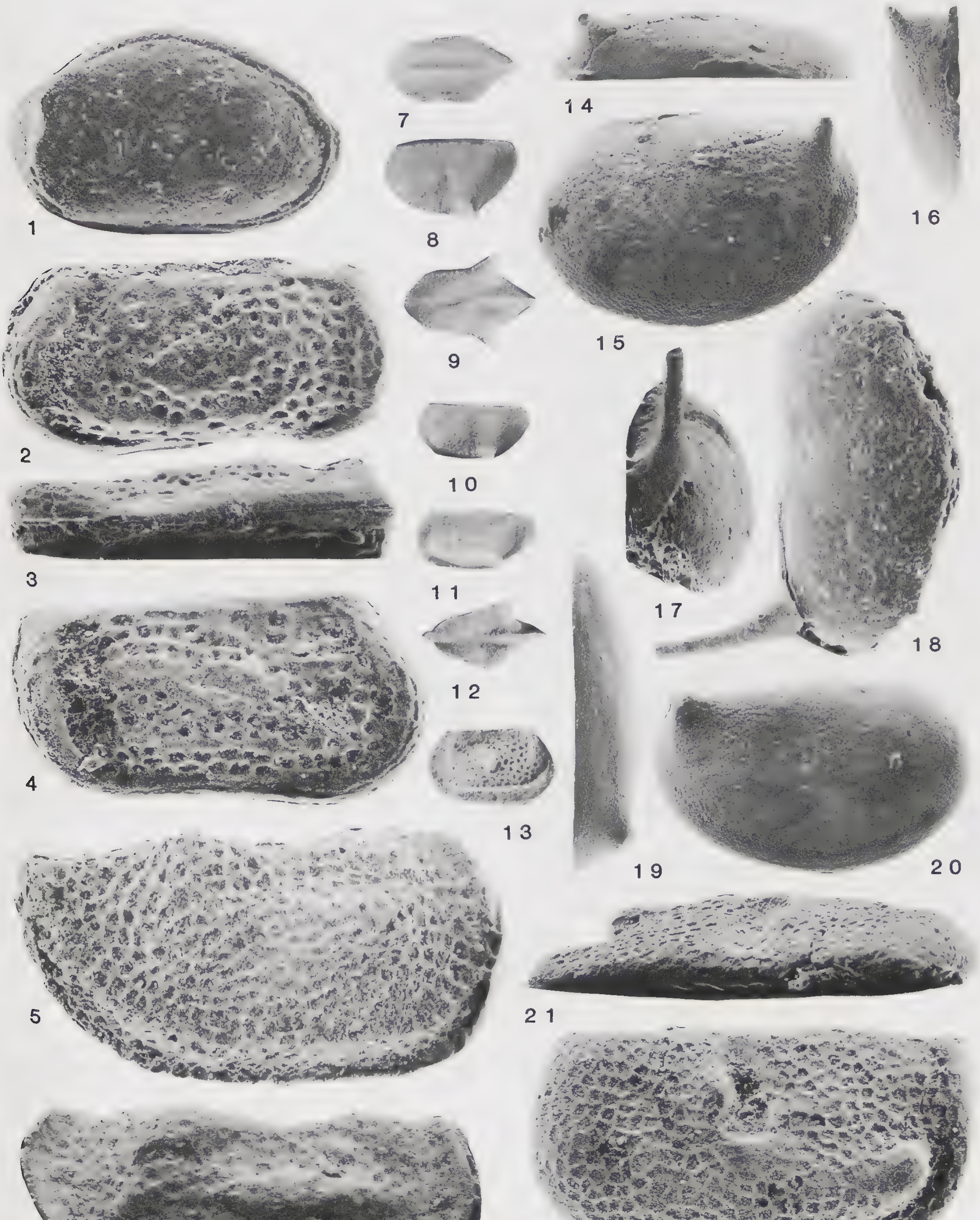
13\. **Amphissites (Amphikegelites) henryi** new species ... 12
Figured Specimen: USNM 168220. USGS colln. 21413-PC. Outside view of left valve, approx. ×30.

14–16\. **"Microparaparchites" reductospinosus** new species ... 18
Figured Specimen: USNM 325055. USGS colln. 21413-PC. Dorsal (anterior to right), outside, and posterior views of left valve, approx. ×90.

17, 18. **Pseudoparaparchites** spp. ... 17
Figured Specimen: USNM 168222. USGS colln. 12920-PC. Posterior and outside views of broken right valve showing a very long dorsoposterior spine, approx. ×150.

19, 20. **"Microparaparchites" reductospinosus** new species ... 18
Figured Specimen: USNM 168221. USGS colln. 21413-PC. Dorsal (anterior up) and outside views of right valve, approx. ×90.

21, 22. **Kirkbyella (Berdanella) ricei** new species ... 15
Holotype: USNM 331108. USGS colln. 12927-PC. Dorsal (anterior to right) and outside views of left valve, approx. ×150.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